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Forthcoming Events.

APRIL 17.

Swansea Technical College Metallurgical Society:—Annual meeting at Swansea.

APRIL 20.

Institute of Marine Engineers:—Ordinary meeting in London. "Bearing Metals," Paper by W. Griffiths, M.Sc., F.I.C.

Society of Chemical Industry (Chemical Engineering Group):—Joint meeting with the Birmingham Branch, at Birmingham. "Measuring Instruments," Paper by W. A. Benton

Institution of Automobile Engineers:—Ordinary meeting in London. "Experiments of Laminated Springs," Paper by H. S. Rowell.

Institute of British Foundrymen.

APRIL 16.

Sheffield Branch:—General discussion on "Principles of Gating and Feeding Steel Castings, with Examples of Comparative Practices," by A. Rhydderch, B.Sc.

APRIL 17.

Lancashire Branch (Junior Section):—Annual meeting at Manchester. "Some Notes on Machine and Plate Moulding Practice," Paper by A. L. Key.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Foundry Trades Equipment & Supplies Association.

Secretary: K. S. Bridges, Avenue Chambers, Southampton Row, London, W.C.1.

Fuel Economy.

There is much food for thought in Dr. Ing. Karl Hejcmana's Paper which is printed in this and the previous issue of the JOURNAL. At the moment there are far too few measuring instruments installed in foundries, a fact which is doubtless responsible in large measure for the lack of appreciation of the basic principles of fuel economy. Dr. Hejcmana has clearly shown the advantage of such a study, for, to cite but one case alone, the coke consumption in the cupolas under his charge has been reduced from 23.0 to 10.5 per cent. Few firms have ever attempted to utilise the heat radiated from cooling castings, yet there is sufficient heat in the average ingot-mould casting to dry an ingot-mould if suitable soaking pits are installed. Again, a second loss is exemplified by the leaving open of mould-drying stove doors all day long after the withdrawal of the charge instead of immediately closing up and taking the necessary steps, such as the closing of dampers, to maintain the residual heat.

The controversy as to the heat generated in the cupola should be capable of immediate and satisfactory solution. A comparison with the ordinary coke-fired crucible furnace would lead one to believe that the cupola is capable of attaining temperatures at least equal to those to be associated with that particular form of melting. Since Swedish bar iron and high-speed steel can be melted in a natural draught coke-fired crucible furnace, even though they be contained in a refractory clay pot, we are inclined to believe that similar, or even greater, temperatures are reached in the centre of a cupola just above the tuyere level. The method followed by Piwowarski of inserting pyrometers at various heights through holes in the cupola casing does not appear to us as being reliable. There is a different and looser type of contact between coke and furnace walls than between coke and coke or coke and metallic charge.

Any excess of cold blast will take the least line of resistance, and will render the mixture flowing up the walls somewhat cooler. The correct method of determining the practical maximum heat generated in the cupola would be to conduct a series of experiments by the placing centrally in the furnace at the tuyere level crucibles containing alloys of progressively higher established melting points.

It may be contested that such information is of but little practical value, but there are still a large number of foundrymen who insist that when making semi-steel the steel part of the charge is first case-hardened to such an extent that its melting point is very materially lowered to a figure approximating that of pig-iron. Whilst we do not deny that a carburising action is present, we do insist that a steel melting can be, and often is, attained in cupola practice.

Another instance where a few heat units can be conserved is by insulating pit fires after the last round has been teemed. Some furnacemen are apt to ignore the amount of heat units required to raise the furnace from 15 to 500 deg. C., but have a real appreciation of the fuel consumption necessary to increase the temperature from 1,000 to 1,500 deg. C.

As a final word, we believe that money expended on measuring instruments is money well spent, and we hope that the manufacturers of these instruments will second the efforts of the Technical Advisory Committee by getting together a series of thoroughly representative exhibits at the forthcoming Foundry Exhibition in June.

Recent Developments in Cast Iron.

Closing Meeting of the Scottish Branch.

At the closing meeting of the Scottish Branch of the Institute of British Foundrymen, held in the lecture hall of the Royal Technical College, Glasgow, Mr. J. G. Pearce, M.I.E.E., director of the British Cast Iron Research Association, delivered a lecture on "Some Recent Developments in Cast Iron." There was a large attendance, presided over by Mr. James Affleck.

Mr. Pearce showed with the aid of a series of lantern slides the influence of carbon in iron, showing particularly the eutectic formation when the amount of carbon is about 4.3 per cent., the eutectic consisting of iron carbide or cementite, and the solid solution of iron carbide in iron or austenite in honeycomb formation. Excess of carbon over the limit of 4.3 per cent. resulted in the formation of free cementite in a honeycomb of eutectic, while less carbon resulted in the formation of free austenite in a matrix of eutectic. The influence of silicon and other elements on the proportion of carbon required to make the eutectic was dealt with, and it was pointed out that ordinary hot blast pig-irons are of the type containing more than the eutectic proportion of carbon, whereas cold and semi-cold blast irons usually contained less than the proportion of carbon required to form the eutectic. This explains to a large extent the tendency towards the use of steel in the cupola.

The influence of the total carbon percentage on the character of the resulting metal was then dealt with, and the advantages of fixing the rate of cooling to yield the combined carbon percentage of approximately 0.9 per cent. were indicated, this proportion giving the pearlitic structure. The influence of composition with particular regard to total carbon, silicon and phosphorus, and of rate of cooling were then considered, the paper differentiating between the improvements obtained by reducing these elements and those obtained by deliberate control of the cooling rate.

Modern High Quality Irons.

The production of Lanz hot mould iron, of Schuz iron and Emmel iron were then dealt with, and the relationships of these different metals explained. The lecturer emphasised the fact that getting the chemical properties of a somewhat similar order from metals of widely differing structures and analyses might lead the unwary to suppose that analysis and structure had really little to do with the matter. The truth was that in all these irons advance was secured by working along lines laid down by metallurgical principles and was governed by the constitution of cast-iron itself. The similarity between such improved irons was more superficial than real. It had been shown that mechanical properties were determined by structure, which was itself governed partly by composition and partly by rate of cooling. With each particular composition adopted, a special rate of cooling had to be employed. Schuz iron had the advantage of having high total carbon and high silicon, but its practical application was limited because it had to be poured in chills. In the Lanz process it was necessary to employ hot moulds. Each type would doubtless find its particular application.

The author concluded by showing with the aid of illustrations the structure of these types of iron, and showed how in castings poured in chilled moulds the tendency was to form crystals at right angles to the mould face in parallel lines. In chilled castings these dendrites were pronounced, but small. In castings made in the ordinary way the rate of cooling was slow, and the dendrites were large, and their outlines were lost in the mass. The dendritic effect could often be seen on the edge of greensand castings, where a slight chill takes place as the metal came against the mould. The reduction of the total carbon and silicon, and the speeding up of the cooling rate tended towards the production of crystal dendrites in castings, and such castings tended to be brittle. Heating the mould enabled this tendency to be offset by lengthening the cooling rate.

In discriminating between different types of high quality iron the repeated impact test had been developed, and preliminary experiments had shown that a high tensile iron might be very brittle, whereas a medium tensile iron gave greater resistance to shock. The best shock-resisting irons appeared to be made largely of virgin pig-iron.

The London Convention.

The Right Honourable Arthur Henderson, P.C., has promised to open the London Convention which is to be held at the Agricultural Hall from June 16 to June 19. As is well known, Mr. Henderson has graduated from the position of a practical foundryman to his present eminent position in the political world.

Sir Alfred Mond has accepted an invitation to be the guest of the Institute at their annual banquet on June 16 to be held at the Hotel Cecil.

The following Papers are to be presented:—

"Quantity Production with Quality or Product," by Arnold Lenz (Saginaw Products Company, Limited, Saginaw, Michigan, U.S.A.). American Exchange Paper.

"Foundry Sands," by Monsieur Lemoine (Paris Foundry High School). French Exchange Paper.

"A Comparison of Some Results Obtained when Improving the Tensile Qualities of Cast Iron," by L. Piedœuf (Belgian Exchange Paper).

"Chemical Reactions in the Cupola, with Special Reference to Fuel Consumption," by Prof. F. C. Thompson and M. L. Becker (University of Manchester).

"Some Notes on the Rate of Cooling of Cast Iron," by J. E. Hurst (Centrifugal Castings Company).

"Some Notes on the Production of Cylinder Pig-Iron to Fracture and Analysis," by E. J. Yates (Goldendale Iron Works).

"Non-Ferrous Metallography," by J. S. Glen Primrose (Bradford Iron Works, Bradford, Manchester).

"Cast Iron for Electrical Machines," by J. H. Partridge (Research Department, University of Birmingham).

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Britain's Largest Ironfoundry.

To the Editor of The Foundry Trade Journal.

Sir,—There seems to be a great deal of doubt as to which ironfoundry in Great Britain is capable of producing the biggest quantity of castings per annum.

Could any of your readers settle the point, please?—Yours, etc. "Interested."

London,
April 13, 1926.

Iron and Steel Output in March.

The production of pig-iron in the United Kingdom in March amounted to 568,500 tons, compared with 502,000 tons in February and 607,900 tons in March, 1925. There were 151 furnaces in blast at the end of the month, an increase of five since the beginning of the month.

The production of steel ingots and castings amounted to 784,100 tons, compared with 703,800 tons in February and 684,700 tons in March, 1925.

Foundry Query.

Rustless Cast-Iron Castings.

Can any reader kindly supply information as to how make castings, such as washboilers, pots and scullery-basins, rustless?

C. M. Hess, Fabrikker,
Vejle, Denmark. Aktieselskab.

We are glad to be able to state that Mr. J. E. Fletcher, who was taken seriously ill shortly before the end of last year, is now recovered.

Power and Heat Problems in the Foundry.*

By Dr. Ing. Karl Hejcmana.

(*Concluded from page 271.*)

Electric Furnace Efficiency.

In four years a reduction of the specific coke consumption to 60 per cent. was effected by simple means. The measurements which were carried out not only helped to reduce the costs of working, but also afforded guiding rules as to the working of the furnaces and bases for the construction of new furnaces, which principles were based on the limit is reached which, in a given furnace with given electric equipment and with given working method, is determined by the metallurgical conditions and cannot be exceeded. The measurements which were carried out on the 6-ton electric furnace, Heroult-Lindenberg system, at the works in question may serve as an example of how in this case also economies may be effected by other methods.

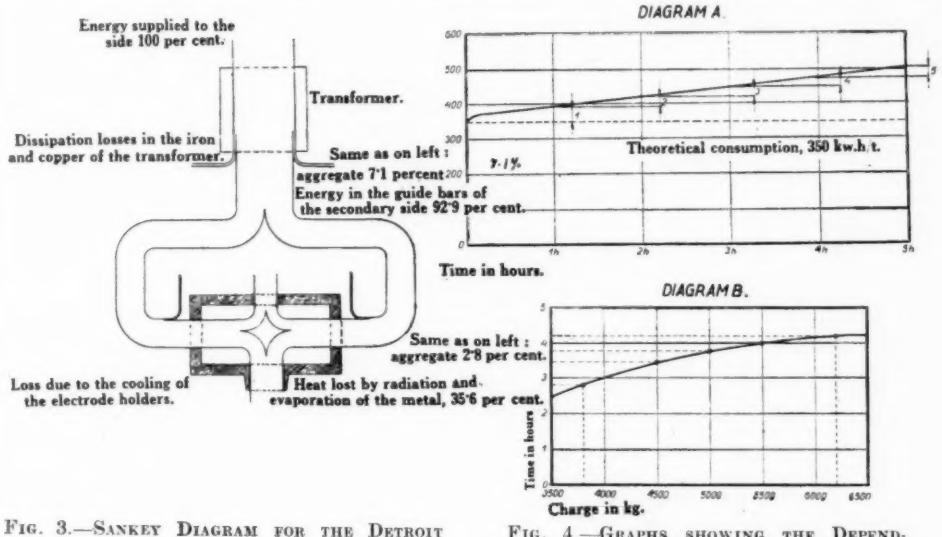
Energy supplied to the side 100 per cent.
Transformer.
Dissipation losses in the iron and copper of the transformer.
Same as on left: aggregate 7·1 percent
Energy in the guide bars of the secondary side 92·9 per cent.
Loss due to the cooling of the electrode holders.
Heat lost by radiation and evaporation of the metal, 35·6 per cent.
Same as on left: aggregate 2·8 per cent.
DIAGRAM A.
Theoretical consumption, 350 kw.h/t.
7·1%
Time in hours.
DIAGRAM B.
Time in hours
Charge in kg.

Fig. 3.—Sankey Diagram for the Detroit Furnace.

Fig. 4.—Graphs showing the Dependence of the Current Consumption Necessary for the Melting upon the Time.

peculiar working conditions obtaining in the foundry in question. The heat balance of the electric half-ton furnace, Detroit system, for the melting and refining of alloys is shown graphically in Sankey's diagram, Fig. 3, working on bronze ingots as final product with the composition Cu 54.5, Zn 40, Al 1, Mn 4.5 per cent.; the distribution of the energy supplied in respect of the metal-transformer losses, cooling, etc.—is also shown. The efficiency amounts to 54.5 per cent.

Both furnaces, which are of an older type, were equipped with transformers of 900-1,000 k.v.a. in accordance with constructional views at the time. The maximum load of the transformer and the amount of energy supplied to the furnace per time unit—about 720 kw. hr.—were similarly determined. If a charge of 5,000 kg. had to be melted, the average current consumption for the melting being 2,760 kw. hr., a period of 3½ hours would be required to convert it into the liquid state.

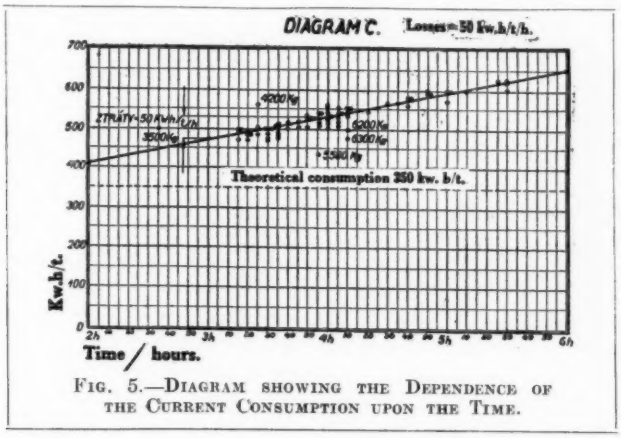

Fig. 5.—Diagram showing the Dependence of the Current Consumption upon the Time.

The losses in every electric furnace, in normal working, form a constant magnitude and are an almost linear function of time. It is, indeed, possible in most cases further to restrict these losses and so to reduce also the consumption of energy per ton of liquid metal; but the lower

The theoretical consumption of energy for the melting is given by the value 350 kw. hr. per ton (including the customary amount of slag), and this consumption would correspond to the actual current consumption if it were possible to melt the entire charge at once.

If the course of the consumption according to the time for melting is represented in diagram-

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* Translated from a Paper read before the Czecho-Slovakian Foundrymen's Association. Professor M. F. Pisek presiding.

matic form (Fig. 4), the consumption curve indicating the dependence on time will ascend almost in a straight line from the point A in accordance with the theoretical value 250 kw. hr. per ton. It is clearly shown by the diagram that with a shorter melting period the average consumption is smaller if the losses are reduced. This can be obtained by the selection of a larger transformer. The construction of electric furnace plants has of late taken this direction, and the following capacities are therefore selected:—

For a 3-ton furnace, a transformer of 1,200 k.v.a.
„ 6-ton „ „ „ 1,800 „
„ 15-ton „ „ „ 6,000 „

Influenced by this idea, the works' engineers instituted measurements and investigations in regard to the conditions affecting the furnaces. Measurements and particulars relating to a whole series of charges were compiled. In consideration of the fact that the consumption is affected by a number of variable factors, these were successively eliminated. The time required for a melting of charges of different amounts, increases according to the line in diagram B (Fig. 4).

If the results of the measurements in diagram C (Fig. 5) are examined, it will be seen that even experimentally the first view was confirmed, and that by shortening the melting period by one hour the current consumption for the melting is reduced by 10 per cent., while by shortening the time to one-half the reduction is 20 per cent. With the average aggregate consumption of 720 kw. hr. per ton, the reduction in current consumption for the entire process is 14.5 per cent.

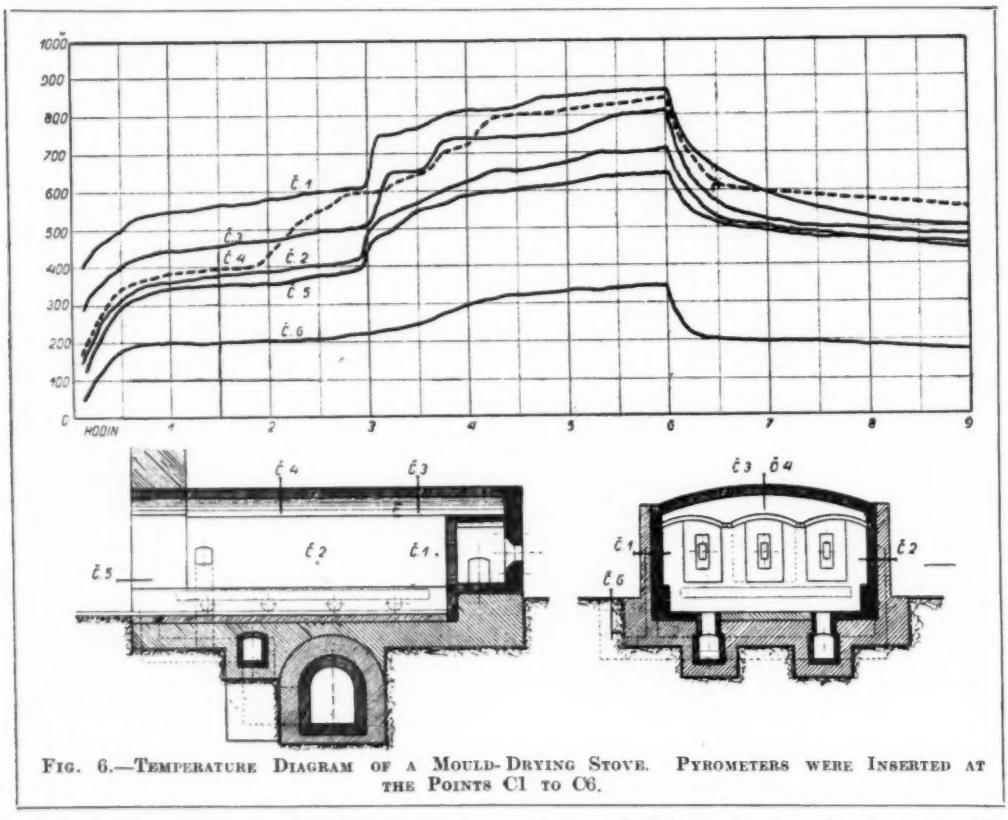


Fig. 6.—Temperature Diagram of a Mould-Drying Stove. Pyrometers were Inserted at the Points C1 to C6.

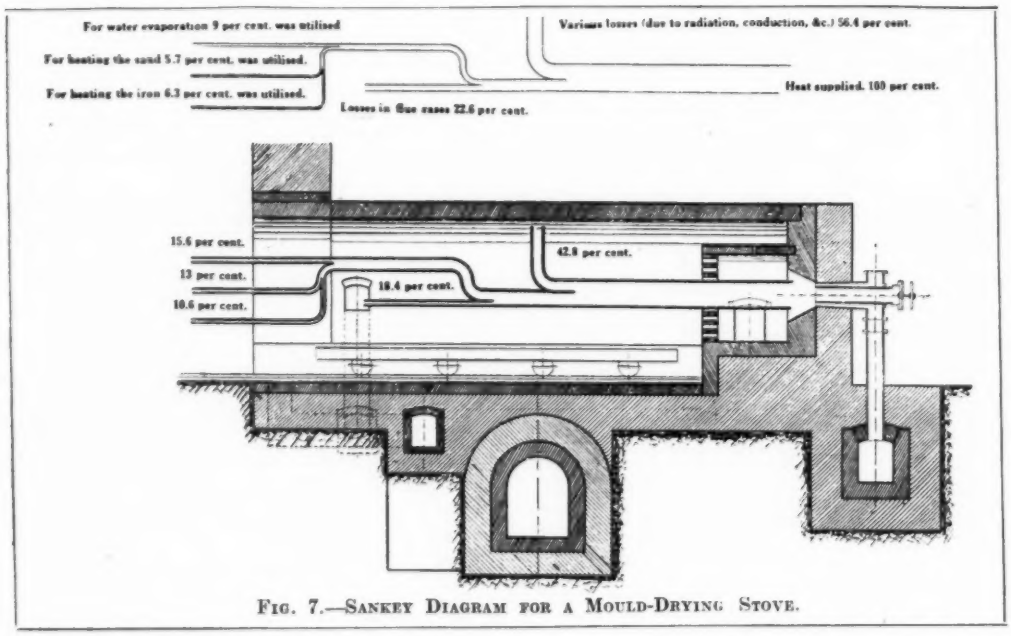

For water evaporation 9 per cent. was utilised
For heating the sand 5.7 per cent. was utilised.
For heating the iron 6.3 per cent. was utilised.
Various losses (due to radiation, conduction, &c.) 56.4 per cent.
Heat supplied. 100 per cent.
Losses in flue gases 22.6 per cent.
15.6 per cent.
13 per cent.
10.6 per cent.
42.8 per cent.
18.4 per cent.

Fig. 7.—Sankey Diagram for a Mould-Drying Stove.

Relying upon these theoretical and experimental investigations, the works staff carried out the alterations indicated and replaced the transformer by a new one of 1,800 k.v.a. The results of the works supervision completely confirm the correctness of the hypotheses.

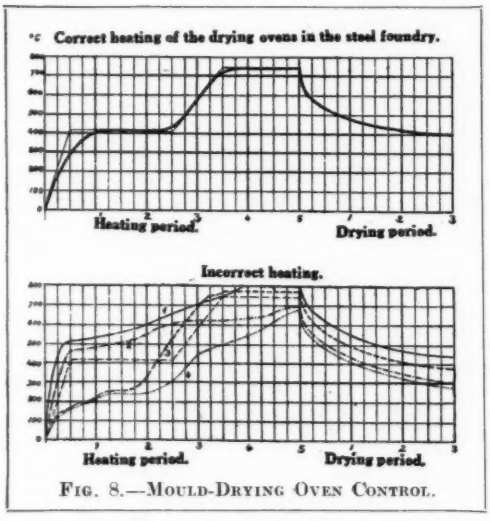


Fig. 8.—Mould-Drying Oven Control.

Correct method : (1) In ½ to ¾ hour increase up to 400 deg. C. (2) 400 deg. C. is maintained for 2 hours. (3) The temperature is increased for 1 hour ; 1½ hours before stopping 700 deg. C. is reached. (4) The temperature of 700-750 deg. C. is maintained to the end of the heating period.

Incorrect method : (1) Sudden drying and combustion. (2) Sudden drying, low combustion. (3) Bad drying, high combustion. (4) Bad drying and combustion.

Mould Drying Stoves.

In foundry work the drying of the bottom moulds involves a great consumption of fuel, and so also do the drying ovens. The fuel consumption for these purposes is very considerable, and it is possible to effect economies by improving the service and the constructional equipment. How this is done in practice was exemplified by the examination of the drying stoves in the steel foundry which are heated with producer gas.

To determine the quantity of gas in the individual furnaces baffle plates were inserted in the gas inlet, and a trustworthy method was devised for determining the degree and extent of the heating up and "holding" periods; the heat distribution in the chamber was measured by a whole series of pyrometers. The course of the heating and cooling is shown by the temperature diagram in Fig. 6, which also indicates the points where the individual measurements were made.

The heat balance of the measurements in two equal chambers, one of which was filled to 12 per cent. and the other to 21.4 per cent., is shown in the following Sankey diagram (Fig. 7).

If we regard as useful heat that which is required for drying, heating the sand, and heating the iron box parts, the heat efficiency in the first furnace is 21 per cent. and in the second 39.2 per cent. The ratio between these two figures gives us a measure of the heat utilisation in the two cases. The quantity of gas used per cubic metre of moulding material was 1,150 cub. m. and 710 cub. m. respectively; from the point of view of heat technics, therefore, the second chamber worked 39 per cent. more efficiently than the first.

The heat measurements in the heating chambers afford not only a criterion of the construction and operation of the furnace, but also rules for obtaining economic working in normal running, in which the measurements must, of course, be limited to those which are characteristic and really necessary for the working of the furnace. Fig. 8 shows various cases of incorrect working, as registered by an iron-constantan pyrometer at two-thirds of the distance from the furnace and 0.3 m. from the arch. At the top is found the normal temperature curve in accordance with which the furnaceman has to regulate the working. Continuous measurements of the temperature by recording pyrometers, as also continuous measurements of the heating period, are an indispensable aid to ensuring a normal furnace working and controlling the service.

The heating process, which is carried out in the drying chamber, is essentially different from the normal working in other furnaces. In the first part of the process in the drying chamber, during which the great part of the moisture is expelled from the moulds, the primary requirement is to facilitate the saturation of the gases with a higher percentage of moisture.

From the Sankey diagram of the two furnaces it will be seen how important from an economic

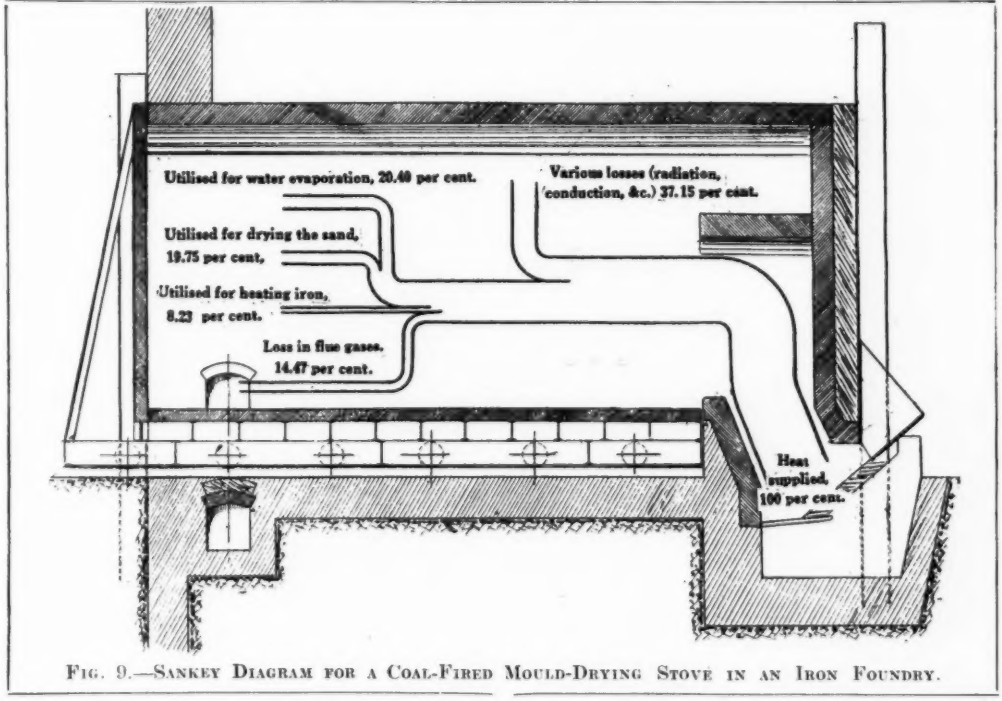

Utilised for water evaporation, 20.40 per cent.
Various losses (radiation, conduction, &c.) 37.15 per cent.
Utilised for drying the sand, 19.75 per cent.
Utilised for heating iron, 8.23 per cent.
Loss in flue gases, 14.47 per cent.
Heat supplied, 100 per cent.

Fig. 9.—Sankey Diagram for a Coal-Fired Mould-Drying Stove in an Iron Foundry.

aspect are the filling of the chambers and the utilisation of their space. At the same time, the Sankey diagram shows that the bulk of the heat losses is due to radiation and to the absorption of the heat by the brickwork during heating and

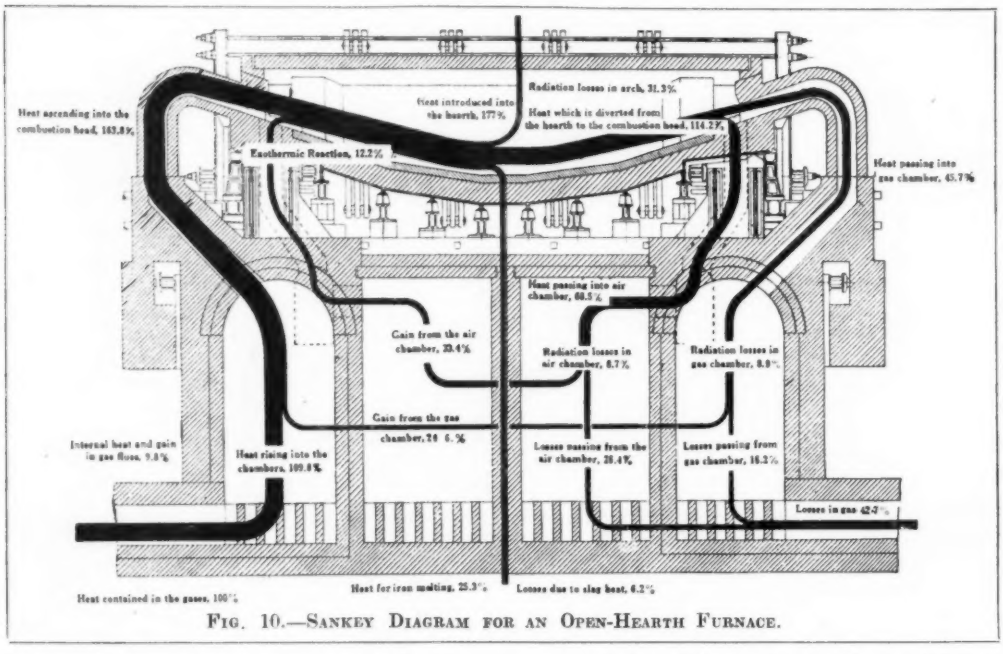

Heat ascending into the combustion head, 163.8%
Heat introduced into the hearth, 177%
Radiation losses in arch, 31.3%
Heat which is diverted from the hearth to the combustion head, 114.2%
Exothermic Reaction, 12.2%
Heat passing into gas chamber, 45.7%
Heat passing into air chamber, 68.5%
Gain from the air chamber, 39.4%
Radiation losses in air chamber, 8.7%
Radiation losses in gas chamber, 8.9%
Gain from the gas chamber, 29 6.%
Internal heat and gain in gas flues, 9.8%
Heat rising into the chambers, 109.8%
Losses passing from the air chamber, 28.4%
Losses passing from gas chamber, 16.3%
Losses in gas 42.7%
Heat contained in the gases, 100%
Heat for iron melting, 25.3%
Losses due to slag heat, 6.2%

Fig. 10.—Sankey Diagram for an Open-Hearth Furnace.

with continuous working—for one heat this item amounts to over 50 per cent. of the consumption. For this reason as few chambers as possible should be heated, and where possible these should be used continuously. It is certainly of advantage to leave the moulds in the chambers after cooling when the temperatures are equalised, but this should not be needlessly prolonged.

The heat losses can be restricted by obviating too rapid cooling of the chambers. This is effected by closing the door of the chamber again after removal of the truck and by suitable construction of the walls and arch. From the standpoint of heat economy the simultaneous working of two drying stoves would be of advantage, the damp moulds of the one stove being preheated by the waste gases of the other, which is at the "holding" period. The radiation heat from the chamber arch can also be used with advantage for drying the mould material.

In grey metal casting the requirements in respect to the drying of the moulds are different, as the maximum temperature of the heating furnace is 300 deg. C. The other working conditions are the same as in the case of drying ovens for steel moulds. (The Sankey diagram of the drying chamber with coal firing is shown in Fig. 9.)

Attention must also be paid to the drying of the bottom part moulds, as the utilisation of the fuel is usually at a minimum here. By using portable ovens with adjustable firing a saving of 60 per cent. may be effected.

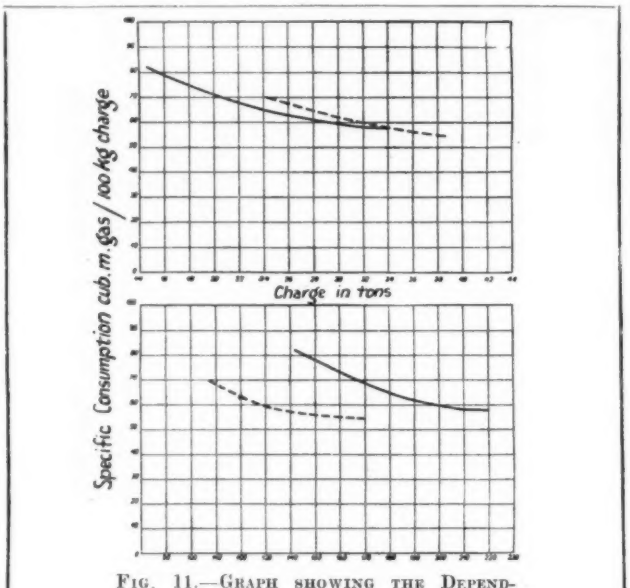


Fig. 11.—Graph showing the Dependence of the Gas Consumption in an Open-Hearth Furnace (Upper) in Relation to Each 100 Kilogram of Charge (Lower) in Relation to Each Kg./hr. per cub. m. of Hearth Area.

Open-Hearth Furnaces.

Figs. 10 and 11 show the results of the measurements and researches made in connection with

an open-hearth furnace, which was heated with producer gas derived from North Bohemian lignite. The Sankey diagram shows the distribution and utilisation of the heat, the gain derived from heat recovery, and the losses in the process.

Fig. 11 shows the dependence of the specific gas consumption upon the amount of the charge with a given type and size of furnace. The most favourable consumption is obtained with the normal charge for which the furnace is dimensioned. In the second diagram there is shown the ratio between the gas consumption for a 100-kg. charge and output in kg./sq. m. of hearth area in one hour. The course of the curve is similar to that in the preceding diagram. These diagrams clearly show that in the open-hearth furnace the load has a great influence upon the fuel consumption.

To ensure an economic working it is necessary to provide for proper combustion of the gases and to regulate the working of the furnace, *i.e.*, to regulate the amount of gas and air introduced. To make this task easier for the furnaceman and to enable its performance to be checked, every furnace in operation must be provided with the requisite recording apparatus. These comprise apparatus for measuring the amount of gas and air, flue gas analysers, draught gauges and pressure gauges. Every furnace requires individual arrangements in the works, and successful results can only be obtained by co-operation of the metallurgist with the combustion engineer.

The diagram showing the heat distribution in the open-hearth furnace indicates that the heat losses in this process are very high, particularly owing to hot waste gases. The combustion engineer must try to reduce these losses by more intense utilisation of the heat in the furnace itself, or by utilising the waste heat. Waste-heat boilers in the flues of the open-hearth furnace naturally lower the temperature of the flue gases and increase the resistance in the plant, so that artificial draught must be used. The efficiency of waste-heat boilers is, of course, much smaller than that of boilers with direct firing; moreover, the generation of steam in these boilers depends upon the working of the furnace. It is therefore necessary, when calculating the economy of the system, to estimate this steam at a correspondingly lower value. The utilisation of waste heat is to-day a dominant problem in heat economy, but it is this very problem which, more than any other, demands in each individual case a precise examination as to economy with respect to the works as a whole as well as to the individual apparatus.

With regard to the furnaces, attention must be directed first of all to the utilisation of the heat and energy in the thermo-technical apparatus primarily for its purpose proper, *i.e.*, generation; then, as a secondary purpose, comes the utilisation of the waste energy, so as to ensure more economic working. It is a different matter as regards conditions in the working of steam power stations and in combined heating and power stations. The introduction of power supervision in the working necessitates expenditure in respect of measuring apparatus, its maintenance, attendance, and calculations of diagrams. It means, moreover, a struggle against the conservative views of the personnel and, in most cases, a struggle for every step in the direction of progress. But it affords a clear view of the working, facilitates its management and control, and effects large economies. The activities of the foundryman and the combustion engineer supplement each other, since they pursue the same aim—improving and cheapening of production.

To Render Cement Waterproof.—Cement may be waterproofed by the addition of about 10 to 12 per cent. of petroleum oil immediately after mixing, but the great objection in most cases is that the time taken for the cement to set is practically doubled. A very effective method of treating damp workshop walls which are already cemented is to coat the wall surfaces with a 20 per cent. solution of paraffin-wax in gasoline. Another successful method is to damp the walls with soapy water. Leave for about 24 hours and then pass a solution of sulphate of alumina over the walls. Repeat this operation several times, according to the state of the walls.

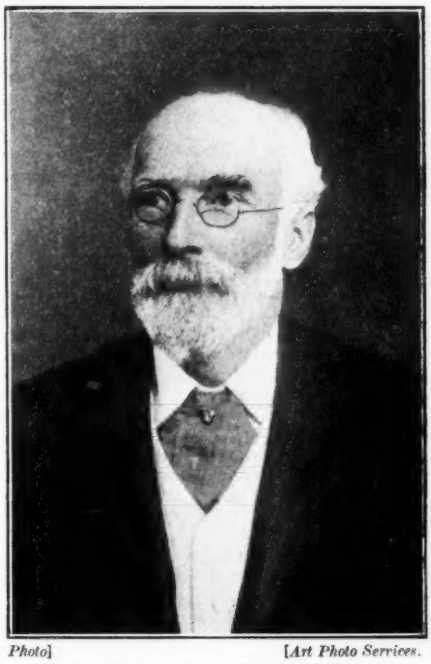
The Iron and Steel Institute.

Award of the Bessemer Gold Medal.

The Council of the Iron and Steel Institute has this year awarded the Bessemer Gold Medal of the Institute to Sir Hugh Bell, Bart., C.B. The medal, the award of which is made in recognition of outstanding services in the advancement of the art of the manufacture of iron and steel, will be presented to Sir Hugh Bell, at the annual meeting of the Institute, on May 6, by the incoming president, Sir W. Peter Rylands, J.P.

Sir Hugh Bell, Bart., C.B., is chairman of the Horden Collieries, Limited, the Channel Steel Company, Limited, chairman and managing director of Bell Brothers, Limited, a director of Brunner, Mond & Company, Limited, Dorman, Long & Company, Limited, the Yorkshire Insurance Company, Limited, North Eastern Steel Company, Limited, Sir B. Samuelson & Company, Limited, Synthetic Ammonia and Nitrates, Limited, Wilsons and North Eastern Railway Shipping Company, Limited, and chairman of Slag Power, Limited.

Born at Walker-on-Tyne, he has been associated with the North throughout his business career. His father, Sir Isaac Lowthian Bell, Bart., was at one time Member of Parliament for North Durham. Between 1846 and 1850 Sir Isaac Lowthian Bell managed the Walker Ironworks. Two years afterwards he started the Clarence Ironworks, and was associated as well with the Washington Chemical Works.



Photo] [*Art Photo Services.*

Sir Hugh Bell, Bart., C.B.

In 1872 Bell Brothers became a limited company, for family reasons. Then in 1899 the business was floated as a public undertaking, in conjunction with Dorman, Long & Company, Limited. The ordinary share capital of Bell Brothers afterwards came into the ownership of Dorman, Long & Company, and the North Eastern Steelworks were subsequently acquired. After being managing director of Bell Brothers, Limited, Sir Hugh became chairman in 1904, on the death of his father.

Not only has Sir Hugh devoted himself strenuously to business, but he has led an active public life. As a member of the Tees Conservancy Commissioners, he represented respectively the Middlesbrough Corporation and Middlesbrough Payers of Tees Dues until 1903. Subsequently he became chairman of the Commissioners, acting as Board of Trade representative, and chairman of the Parliamentary Committee. Various public honours have been bestowed on Sir Hugh Bell by Durham and Middlesbrough, and since 1906 he has been H.M. Lieutenant of the North Riding. He was also an original member of the Industrial Council for the Settlement of Labour Disputes, a past-President of the Iron and Steel Institute, and is the present chairman of the Statistical Committee of the National Federation of Iron and Steel Manufacturers.

National Physical Laboratory.

Annual Report.

The Report of the Executive Committee of the National Physical Laboratory for the year 1925, just issued, states that the work of the Laboratory continued to develop during the year in a satisfactory manner, and the demands made by the various Research Boards and Committees of the Department of Scientific and Industrial Research continued to grow. The volume of tests and investigations carried out for firms and other outside bodies also has been well maintained. The Report reviews the work of the various departments, including physics, electricity, metrology, engineering, metallurgy, etc.

Engineering and Metallurgical Research.

Hardness Tests Research.—Further experiments have been carried out during the past year with diamond indenting cones in order to develop a reliable method of measuring indentation hardness on materials which are too hard for satisfactory tests with steel balls. Using loads of 60 kgms. to 150 kgms. on five different diamond indenting tools, it has been found that the effect of the adhesion or friction is much smaller on hard steels than on mild steel or copper, and that variations in initial surface lubrication conditions that may arise in practice have no appreciable effect on the results obtained. The value of μ, the co-efficient of adhesion or friction in the indentation, has been found to be 0.1 for all materials that have been examined of Brinell number over 350, compared with 0.32 for mild steels and 0.25 for annealed tool steel. The investigation is not yet complete, but it already appears that accurate determinations of the indentation hardness of the hardest steels can be obtained by measurement of diamond cone indentations in the test materials.

Lubrication Research.—As a continuation of the work on the effect of pressure and temperature on the "seizing point" of a journal, a series of experiments has been made in order to examine the manner in which the pressure distribution over a heated journal is affected by speed. The first series of tests was made on a 2-in. journal at surface speeds varying from 5.2 to 17.4 ft. per sec. The plotting of the pressure distribution curve over the whole arc of contact involves a lengthy series of observations, and difficulty was experienced owing to the change of shape of the bearing, which has a very great effect upon the maximum pressure of the oil film. The effect of speed was shown by taking observations for one position of the bearing at each speed in succession, so that the change in shape was small during the series of runs. After the conclusion of the tests the surface of the bearing was explored, and although it did not show signs of any appreciable abrasion, the contour of sections at the arc of contact showed a curvature agreeing closely with the curvature of the journal. The appearance of the bearing under these conditions was, from a practical point of view, that of a well "run-in" bearing, but it could no longer be considered to consist of a circular journal running in a circular bush of slightly larger radius.

The general conclusions drawn from the observations were as follow:—(1) The temperature of minimum friction increases with the speed. (2) The co-efficient of friction is nearly independent of speed. (3) The pressure at the temperature of minimum friction is nearly independent of speed. (4) The general shape of the pressure distribution curve is independent of the speed. (5) The arc of contact at the temperature of minimum friction is independent of speed. (6) The effect of "running-in" is to indent the loaded surface to the shape of the journal and to increase the maximum and mean pressures on the mid-section. In order to increase the range of speeds, a large journal has now been prepared which is 7½ in. dia. by 8½ in. long, and which will give a surface speed of 66 ft. per sec. at 2,000 r.p.m.,; this is about the maximum speed used in practice. This journal will also be used for observations upon the aspect of the bearing at extremely low loads, which it is hoped will throw light on certain theoretical points which are now obscure. Investigations also were carried out in connection with the sliding friction of dry metal and graphite surfaces at high temperatures, the effect of lubricant in rolling friction, and the determination of co-efficients of static friction of lubricated surfaces.

Other research work includes an investigation for the Springs Research Committee of the Department of Scientific and Industrial Research. Considerable progress has been made during the year in the investigation of the mechanical properties of standard spring steels, and the results of tests on 0.8 per cent. carbon steel, oil quenched, and on a silico-manganese steel, both oil and water quenched, have been communicated to the Committee. The results of the fatigue and impact tests are of distinct interest, as very few tests have been carried out in this country on steels of this nature. It may be mentioned that the ratio of the fatigue limit, under reversed stresses, to the ultimate tensile stress has been found to be 0.50 for several of the heat treatments investigated, although the tensile strengths of the materials concerned were over 80 tons per sq. in. Investigation was made into the mechanical properties of materials at high temperatures. The properties of Armco iron and a 0.17 per cent. carbon steel have been thoroughly explored. The results obtained show that the variations in mechanical properties with temperature are very similar in character in the case of all these materials.

Iron Alloys.—Work has been done on the further investigation of the alloys of iron and chromium free from carbon. In a series of alloys containing up to 50 per cent. of chromium, prepared from electrolytic iron and electrolytic chromium in the high-frequency induction furnace, it has been found that oxide particles are present, in spite of the fact that the melting operations were performed *in vacuo*. This impurity can be removed from each alloy by allowing a stream of specially purified hydrogen to pass over the surface of the molten metal for several hours. Although alloys containing up to 30 per cent. chromium have been successfully treated, the difficulties increase with rising chromium content.

The Mechanical Properties of an Alloy of Nickel and Copper, with Special Reference to Creep.*

By H. J. Tapsell and J. Bradley, B.A.

Summary.

The Paper deals with the results of some mechanical tests carried out on a synthetic alloy of nickel and copper (approximately 70:30), containing 2.35 per cent. of manganese, at a range of temperatures between air temperature and 700 deg. C. to 800 deg. C. The tests consist of the following:—Ordinary tensile, torsion, impact, impact hardness, fatigue under reversed stresses and "creep." Attention is given to the study of the "creep" of the nickel-copper alloy, and determinations of the limiting creep stresses have been made between the temperatures 400 deg. C. and 700 deg. C. The Paper indicates the large difference existing between the apparent ultimate strength, as determined by tests made at the ordinary rate of loading, and the safe strength, or limiting creep stress, obtained from tests made under constant loading conditions over long periods. Comparisons of the results obtained in the ordinary tensile tests and the creep tests on the nickel-copper alloy, and the results of other experiments on Monel metal and other alloys, are given at the conclusion of the Paper.

The tests described form part of an investigation of the mechanical properties at high temperatures of several ferrous and non-ferrous materials, and the results of the tests on the nickel-copper alloy have been given in this Paper mainly for the purpose of showing that such a synthetic alloy of nickel and copper can be made, which will give a satisfactory performance at high temperatures.

The B.C.I.R.A. Scottish Committee.

In addition to the names which we published last week, there is to be added Mr. John H. Wilson, of Messrs. A. F. Craig & Company, Limited.

* A Paper presented to the Spring Meeting of the Institute of Metals.

Aluminium Foundry Practice.*

By George Mortimer.

(*Continued from page* 281.)

Melting Practice.

This is the crux of the matter, and if furnace hands are trained to follow a few first principles right from the start, it will mean materially less uphill work later on. It is now generally recognised that aluminium cannot readily be "burned" in the accepted sense of the term. This may also be accepted in regard to the common alloys of the metal: the only damage likely to occur in the case of the alloys mentioned being loss of zinc through volatilisation. The mere raising of temperature does not appear to affect the metal or its alloys permanently to any appreciable extent. What does damage the melt is the extent to which it absorbs gases, which largely hangs on the temperature attained and the period during which it is maintained in a molten condition.

There is this fundamental fact to bear in mind in connection with aluminium melting. The metal absorbs gases like a sponge at high temperatures: hydrogen, nitrogen and oxygen; and the worst of them is oxygen. The affinity of aluminium for this gas is well known; it was this factor that caused the abrupt removal of the Messines Ridge from the path of British troops during the war. It is the chief factor in most industrial thermit reactions, and the chief obstacle to be

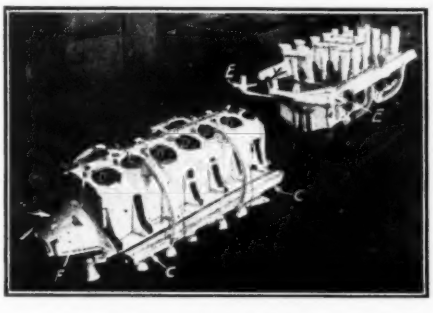


Fig. 1.—Liberty Crank Case showing the Forest of Risers used and the Horn Gates.

overcome in welding and soldering the metal. In foundry work it is handy to remember one small fact. If the film of oxide that instantly forms on all aluminium were not a simple and effective check to further action, there would not be an ounce of the metal in the world to-day.

The great difficulty about alumina, or oxide of aluminium, is that it has much the same specific gravity as the melt: once stirred in there is no very effective method of getting it out again. On routine production, therefore, oxide with its detrimental effects on castings tends to accumulate. It cannot entirely be excluded, but it can be kept within non-detrimental limits by following three simple rules.

Avoid Overheating and Overstewing.

The melting point of these alloys ranges about 650 deg. C. For general purposes it is seldom necessary to go beyond 700 deg. C. This latter may be exceeded by at least another 100 deg., provided attention is given to stewing.

Aluminium should not be kept in a molten condition too long. Even at low temperatures oxidation is proceeding steadily, but at a steadily decreasing rate if the surface is left undisturbed. The scum of oxide and dross is the simplest and one of the soundest checks to further action, and continual skimming merely doubles or trebles dross losses. When the mould is ready for the metal, skim the pot thoroughly and stir for a short time, taking care to disturb the surface as little as possible. Pour with the shortest stream and the least possible turbulence. Do not quite empty the pot: minor foreign inclusions, iron complexes, slight scalings from the sides of the pot, tend to collect at the bottom. If they go into a good casting they may cause a weakness or a hard-spot on machining. It is better to ingot the last inch or so of metal at the end of the day, and use it for low grade work. Obviously also it is better to allow such inclusions to sink than to keep them up in the melt by continual stirring; an additional reason for leaving the melt undisturbed until just before ladling.

Temperature Control.

It will be seen from the above that success hangs on rather keener control of temperatures than is normal or necessary with brass. For this reason it is strongly recommended that melting should be under pyrometric control, for there are few metals so difficult as aluminium to gauge in matters of temperature. The most experienced furnace hand will make a mistake on the first sunny day after a dull spell, and it is wise to eliminate as many potential sources of trouble as possible from the start.

The necessity for close control of temperature

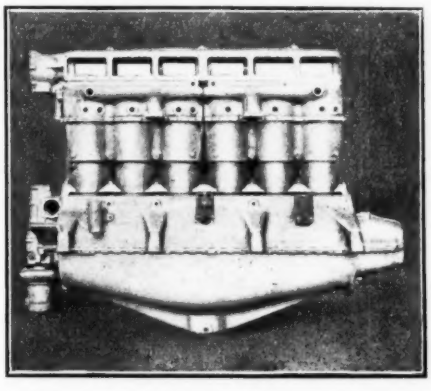


Fig. 2.—Aluminium Castings for the Siddeley-Puma Aero Engine made from 3L11 Alloy.

influences the choice of melting plant. There is no standard furnace for the melting of aluminium. Ordinary brass furnace house equipment produces thoroughly good castings, but control being cumbersome, most founders sooner or later evolve a more readily handled type for the lighter metal. Whether these are fixed or tilting, employ pots of iron or plumbago, are fired with gas, fuel oil or electricity, does not greatly matter here. The importance of these points lies in the direction of economy rather than technical preference, and they are largely settled by local conditions, personal prejudice, or convenience of supply. The main essentials are cleanliness, ease of control and reasonably rapid melting.

Plumbago Crucibles.

Aluminium is perhaps preferably melted in plumbago crucibles because of their great cleanliness It is very difficult to contaminate the melt from the walls of plumbago crucibles, and for this reason they are used for very special work in connection with air-craft castings and similar high-grade products, such as are shown in Figs. 1 and 2.

The useful life of plumbago crucibles is short, however, and their initial cost is high. The thermal conductivity, and therefore the rate of melting, falls off rapidly after a couple of weeks' work. This happens long before the crucible is mechanically worn out, and it introduces two factors; firstly, either a sound pot must be replaced, or a heavy fuel-bill faced; secondly, the time taken to effect melting becomes equivalent to stewing. Although a new plumbago crucible does not contaminate the metal, therefore, it is within ordinary experience that after a few weeks'

* A Paper read before the Lancashire Branch of the Institute of British Foundrymen, Mr. J. Masters presiding. The Author is associated with Messrs. William Mills & Company of Birmingham.

service it can, in effect, contaminate the melt through undue time in melting and consequent absorption of gases.

By far the greatest proportion of the world's aluminium castings is melted in iron pots. These are relatively inexpensive, give a longer, useful life, and melt at a reasonable and consistent rate throughout.

Iron Pots.

From the economical standpoint iron pots are immeasurably superior to graphite crucibles; from the technical point of view they have the advantage of melting more rapidly throughout their useful life, and so cutting the time factor in the matter of stewing. This advantage is, however, offset by the basic drawback of iron in contact with molten metal, the risk of taking up iron in the melt.

Iron forms with aluminium and its alloys hard complexes which crystallise out in the form of needles and plates, causing drawn and cracked castings, local weaknesses, and "hard spots" on machining, where the compounds have chipped off the sides of pots and gone into the castings. It is therefore essential to keep the iron content low in the purchase of the ingot, and to add as little as possible in the normal routine of the foundry.

This, fortunately, is readily managed by the coating of the pots with some neutral wash, of which there are many available. Probably the

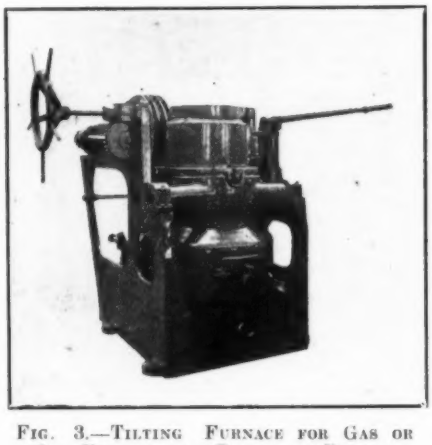


Fig. 3.—Tilting Furnace for Gas or Oil Fuel, using Plumbago Crucibles (Monometer).

most convenient is a thin dressing of graphite wash, followed by a thin coat of whiting and water glass. The pots should be thoroughly scaled at least three times a week, and given a lighter coating on the above lines. Do not make either wash too thick, or apply too freely, as this increases the risk of chipping off into the melt. Needless to say, this precaution applies equally to all iron ladles, stirrers and skimmers used in contact with the metal, and in connection with these it is well to remember to coat them well up the handle.

Given the above precautions, applied rigidly and periodically, there is little danger of any iron of practical import being taken into the melt. Apart from the showing of daily analyses, this is proved by the life of such a pot set against the great tonnage of metal melted during that life; iron pots practically always fail from the exterior, through the action of furnace gases. One further point is to eschew the practice of skimming crucibles, before pouring into moulds, with a bent strip of iron. It is often the handiest thing, and may undo all the precautions taken in the furnace house. A chip of wood is as effective, and does no harm.

The Reverberatory Type.

A third basic type of furnace, deserving mention because of its growing popularity in regard to aluminium melting, is the reverberatory. In this type (Fig. 4) the flames impinge direct on the metal, and melting is very rapid. Since the furnace consists mainly of a cast-iron container lined with firebrick, it is obviously cheap. The linings last about a year, and are easily renewed at low cost; the type is, therefore, economical in upkeep. Melting is more rapid than by any other method, and heat losses are at a minimum, so that running costs are low. Given a slight increase in dross losses over the types previously described, the reverberatory still remains the most economical in fuel labour and upkeep charges of any of those in common use, and, in addition, it takes up the least floor space for a given melting capacity.

The reason the reverberatory has not superseded others entirely, is simply the fact that the furnace gases are in direct contact with the melt. In the light of previous remarks any hesitancy to adopt the type would appear pardonable. That the principle is not necessarily detrimental, however, is indicated by the fact that many thousands of tons of aluminium and its alloys are melted annually in reverberatory furnaces of all capacities, and that as far as tensile and elongation tests carry one, little difference is noted either way between metal melted thus or in plumbago crucibles.

It is but fair to bear in mind, when criticising this type on theoretical grounds, that all aluminium is melted in the presence of some sort of atmosphere, and that the reverberatory alone offers a convenient and reasonably precise control over the composition of that atmosphere.

The type is not fool-proof. It will be seen that by mal-adjustment of the burners it is quite an easy matter to produce an oxidising flame, to reach high temperatures very rapidly, and to soak the melt for some time under these highly detrimental conditions. Given that this is duly

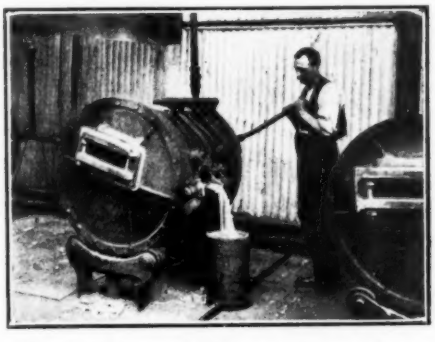


Fig. 4.—Melting Furnace of the Open Flame Tilting Type (Selas Turner).

recognised, however, and that there is intelligent supervision and good furnace discipline, the reverberatory can give excellent and consistent technical results on routine general work, and there is no doubt as to its economy.

The Importance of Pouring Temperature.

Whilst emphasising the importance of pyrometric control of melting, it will not be out of place to refer to the still more important question of pouring temperature. If a casting is melted and poured at a high temperature it will probably turn out porous under hydraulic test, or even cracked. It will certainly be "drawn" where sections of different thickness meet, and it will certainly have a dull finish. Test bar results will be below par, and the average verdict would be that the metal had been "burnt" in melting.

This verdict would be wrong, and it can be proved by remelting that casting under controlled conditions and pouring it again at the lowest temperature at which it can be successfully run.

If the metal has been correct from the start it will then be found that the casting is neither cracked nor drawn, and that it will stand a reasonable hydraulic test and possess its specified physical properties. Finally, it will have recovered that best practical sign of a well-run casting, a bright silvery lustre as it comes from the mould, all of which suggests thoughts which are usefully followed up. There are three main reasons for keeping the pouring temperature as low as possible.

Effect of Occluded Gases.

Firstly.—The metal absorbs gases. These gases have a tendency to leave the metal as it cools.

The lower the temperature, therefore, at which pouring occurs, the lower the volume of gas likely to be frozen into the casting when it sets.

Effect of Total Shrinkage.

Secondly.—The total shrinkage in the mould is a function of the pouring temperature. If, for instance, a casting were poured at 1,000 deg. C., it would have to contract some 3½ per cent. *before* it reached 700 deg. C., which is a fair average temperature for pouring aluminium castings. This means feeding of an order which is seldom attained in practice, and so one would get a casting either cracked and drawn here and there, and/or with an open grained and porous structure. In a metal like aluminium, where the total shrinkage is on the high side, the more one can shave off it before it enters the mould the better.

Effect of Slow Cooling.

Thirdly.—The hotter the metal, the more it will heat up the surrounding sand before setting. Thus the casting will set more slowly than it need; it will take some time passing through its solidification range, and this has a two-fold effect. In the first place, the gases referred to above tend to come out of solution just in time to be frozen into the casting in the form of minute pinholes—the "speckey metal" so familiar to aluminium founders, and the subject of many quite unjust accusations in regard to lack of cleanliness in melting or the use of second-rate material. In the second place, metal which freezes slowly through its solidification range has a tendency to form larger crystals than metal abruptly chilled. Both effects make for a more porous casting than would be obtained by pouring at a lower temperature, which would allow solidification to occur very soon after the metal had reached its appointed place.

For the above reasons the pouring temperature becomes a matter of first importance, and on intricate and important work it is recommended that the best pouring temperature be found by experiment, fixed for that job, and checked every time by a pyrometer. The effect of this on foundry routine means a definite saving in wasters.

The usual type of iron-constantan pyrometer, enclosed in an iron tube, is best for the rough handling of a furnace house. For gauging pouring temperature, however, this type is too slow reading, and an ordinary iron-constantan couple works more satisfactorily, given reasonably careful handling. The two wires are used bare, and they may be used throughout their length if welded together from time to time as the junction burns away. With this type one precaution is necessary. The couple must not be immersed in the metal to any depth, or the current is short-circuited by the molten metal and a false reading results. Carefully separate the wires for four or five inches above the junction, and dip only the welded tip into the melt.

The substitution of scientific control for the personal factor wherever possible certainly lightens the task of the management, but is a fool's paradise unless the scientific apparatus employed is kept up to the mark. Pyrometers are notoriously fragile and capricious instruments, and in the foundry they receive more than the average rough handling. They should therefore be periodically checked against a "master," and a wise organisation will see that this "master" is also checked for accuracy from time to time, against some useful fixed standard such as the freezing point of pure aluminium (658 deg. C.), and that of fused common salt (801 deg. C.).

(To be continued.)

Standardising Pattern Equipment.

Attempts are being made in the United States of America to standardise the following pattern-making items:—

(a) Marking pattern surfaces, which, though not machined, are to be accurately gauged.

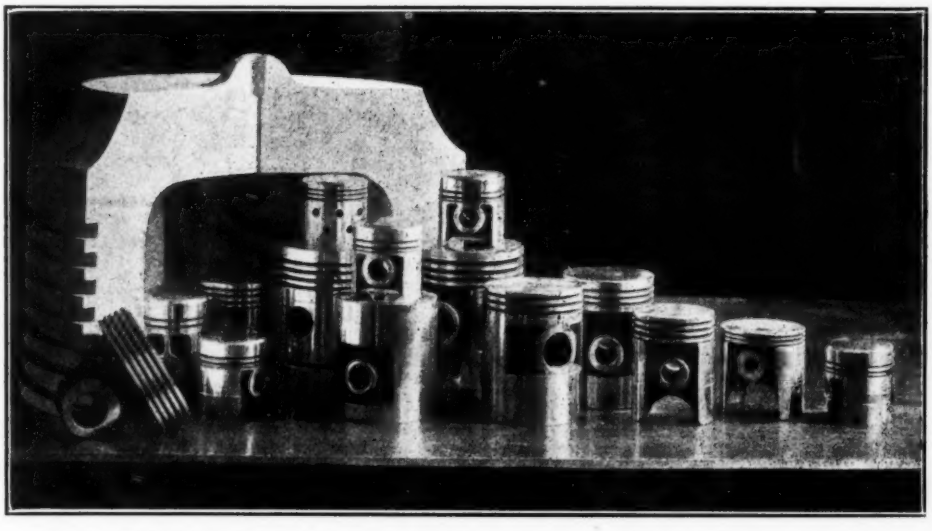


Fig. 5.—Heat Treated "Y" Alloy Pistons from a few Ounces to 2½ cwts. for Diesel Engines.

(b) Marking parts of patterns which are seals of chills or metal inserts.

(c) Formulæ for shellacs and paint ingredients to give colours as called for by standard colour markings.

(d) Styles of letters and figures for marking patterns.

(e) Fillet sizes to be used in connecting various pattern wall thicknesses for core print sizes for metal patterns.

(g) Dowel-pin sizes for metal patterns and core boxes.

(h) Pattern plate sizes.

(i) Size and shape of lugs on pattern plates.

(j) Thickness of pattern plates.

(k) Location and size of vibrator holes in plates.

(l) Series of flask sizes.

(m) Pin centre locations.

(n) Pin sizes.

The Committee dealing with this work will report to the International Congress, to be held in Detroit next September.

In an official statement issued by the London Midland & Scottish Railway Company regarding the extensive scheme now being carried out of rebuilding and reorganising their Crewe workshops, it is stated that when the alterations are complete the new works will be the largest locomotive building and repairing establishment in the country, covering 160 acres. The main features of the new building are the steel works and the locomotive erecting shops. The new erecting shop will measure 850 ft. by 193 ft.

XUM

A Glimpse into a Non-Ferrous Foundry.*

By J. D. Frame.

(*Continued from page* 261.)

Copper forms with other metals a series of alloys far more numerous and important than that of any other metal. This may be accounted for by its red colour, high malleability, ductility, toughness and softness, and tenacity, which properties it imparts in a great measure to many of its alloys, when united with metals opposite to it in character. The very properties which make copper so useful are sometimes a disadvantage for certain purposes; for instance, the toughness and closeness of grain makes it more difficult to turn in a lathe than brass and its softness makes it unfit to be used alone for making castings subjected to great wear and strain. In the vast majority of cases in which pure copper is used, it has to be melted and cast into moulds of various kinds in order to prepare it for further treatment. The difficulties in producing sound castings are so great that it can only be successfully manipulated in the hands of very skilled and experienced workmen. Great attention has been directed to this subject of late years in consequence of the demand for solid drawn tubes, rollers, etc., and different physics have been added to the copper in melting with a view to overcoming the inherent defects.

Modern practice in producing gun-metal castings has resulted in the exclusive use of copper and tin. They should be very tenacious, with sufficient hardness and elasticity to resist distortion. They are indifferent to ordinary chemical influences. While the addition of a third metal may be useful in strengthening one particular property, it may be injurious to the required properties taken as a whole. The addition of a little phosphorus is very useful to this alloy as a deoxidiser and purifier. Zinc is used in the manufacture of copper-tin alloys for bearing purposes, but this has to be used carefully, so that it will not deteriorate the wearing properties of these alloys, for if in excess the bearing wears very quickly; from 1.5 to 2 per cent. is ample as a deoxidising agent, and should not be exceeded.

These personal observations are purely practical, but in this field the author is one of many foundrymen who would welcome more definite and sustained co-operation in its investigations into the gun-metal alloys for bearings. One can solicit very little information from modern text-books, and upon such a complex problem opinions are divided. If this co-operation were sustained, foundrymen would obtain a higher state of efficiency in the gun-metal alloys. The standard alloy of 88 copper, 10 tin, and 2 zinc is only on the fringe of more complex alloys in the higher tin groups.

The analysis of the gases obtained by heating pure copper resemble that of the gas obtained from the copper-tin alloy, and this suggests that the gases which cause unsoundness in gun-metal are actually in the copper group. The volume of gases is also about the same, and when once in the metal it is almost impossible to extract them. Zinc and tin act as deoxidising agents to copper, and thus reduce the cuprous oxide and become themselves oxidised in the process. Zinc oxide comes to the top, and is skimmed off with the tin oxides. Cuprous oxide, on the other hand, is soluble in molten copper, and only separates after the alloy commences to solidify. This gas only attacks the delta constituent, the alpha being impervious to gas holes. Alpha and delta being the structure of high-tin alloys, we find the alpha constituent solidifying first. This probably causes the gas to be driven from the alpha constituent into the delta constituent, and on solidification the gas escapes, leaving local cavities where the metal is farthest away from quick solidification. If founders could solidify gun-metal castings as rapidly as the chilled ingots, they would minimise this escape of gas, and as a result we would have, as near as possible, a homogeneous casting.

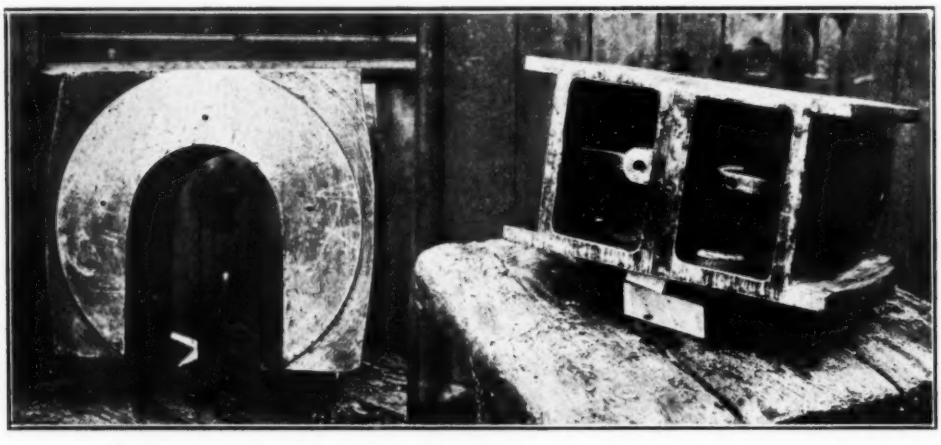


Fig. 1.—Two Views of a Pacific Axle-Box made from Gun Metal showing Clearly the Unequal Section. These Axle-boxes have been Running Approximately 200,000 Miles with the L.N.E.R.

In the design for large gun-metal castings, such as Fig. 1, much assistance towards a "sound job" would be given by uniformity of sections—variations of thickness do not help foundrymen, and are the root cause of many flaws in the gun-metal group. The outlined metal flaws are wholly accounted for by the varied times of freezing; even in an ingot or chilled test pieces there are variations not so pronounced, however, as in castings. Gas holes being the premier trouble in gun-metal, should not be confused with other gases so numerous and of different origin from the gas escaping during solidification of the metals. For example: (1) Water gas (steam) due to moisture in the moulding sand which can be eliminated; (2) gases from the various cores, and if they have no free exit during casting, there will be serious segregation, and also serious blow-holes appearing through the body of the metal; (3) sands, which on contact with the metals become glass, and form oxides; (4) opinion is that oxygen gases play a considerable part in the cause of unsoundness in gun-metal castings. It is thought if it were permissible to use a strong deoxidising agent before casting, it would help to eliminate the gases from the crucible before casting. This, however, coupled with pursuits of the chilling methods and the necessary assistance of the designer in the uniformity of sections previously stressed, will help to solve this serious problem.

* A Paper read before the Scottish Branch of the Institute of British Foundrymen, Mr. Affleck presiding.

In comparison with the steel group, one cannot adapt normalising towards gun-metal bearings. Any attempt in this direction destroys their vital composition. If the normalising process be applied to axle box or slide valves, by treating them in a temperature of 700 deg. C. for half an hour, then the result is to bring the whole of the delta into one alpha solution. In effect, it increases ductility and malleability only, and gives a stronger metal, but it is at the cost of the durability of the initial structure, viz., as a bearing metal, which is the distinct property of the delta constituent; it has meant the sacrifice of an essential factor. It is obvious that this must not be sacrificed, as would happen in any attempt at normalisation. Recent practical tests on modern locomotive slide valves confirm this, and prove conclusively that any such treatment was abortive as applied to non-ferrous alloys when a bearing metal was desired.

The tensile test for high tin alloys is not exactly what it should be, and that a load test or Brinell test for hardness would be of more value for this class of material. The reason for this opinion is the uneven distribution of the delta structure. Temperatures have been very often discussed, and it is thought that there is no constant in casting temperatures, but they must vary with weight of the casting.

It is stated that some of the ancient bronzes have been found on analysis to contain a small percentage of iron, but it does not appear that any traces of manganese have ever been discovered. It is thought probable that the ancients knew that the addition of iron to bronze would increase its hardness, and introduced it for that purpose

Iron, Manganese and Brass Alloys.

Inventors have proposed combinations of iron with brass alloys, and some have also introduced manganese by reducing the black oxide of manganese and combining it with the copper. However, none of these alloys appears to have been brought into permanent practical use. It is more than a hundred and fifty years since James Keir proposed an alloy—100 parts copper, 75 parts zinc and 10 parts iron—and in later years, Sir John Anderson, when superintendent of the Royal Gun Factories, carried out a number of experiments with similar alloys, and with some very good results, but none of them appears to have been used consistently commercially. The addition of iron unquestionably increases the strength and hardness of these alloys, but according to some experiments made a few years later by Mr. P. M. Parsons, they would appear to acquire these qualities at the expense of ductility and toughness, and it is probably on this account that this class of alloys had not come into general use up to the time of Mr. Parsons' experiments. Mr. Alex. Parks, and Mr. J. D. Morris Stirling, both eminent metallurgists, appear to have been the first to propose and carry into practice, the use of manganese. Mr. Parks combined manganese alone with copper, and used this alloy to form improved alloys of brass and yellow metal of which to make sheathing, wire, nails, and tubes. Mr. Stirling, in 1848, proposed to use manganese in various alloys in which iron was present. At first, he combined about 7 per cent. of iron with zinc, and added to the copper a small percentage of manganese, by reducing the black oxide of manganese with the copper in the presence of carbonaceous materials, and then added to it the requisite quantity of the iron and zinc alloy to make the improved brass required. Mr. Stirling's idea was to combine the iron with the zinc by fusion, but in practice, he found a more ready means of procuring the zinc and iron alloy by employing the deposit found at the bottom of tanks containing the melted zinc for galvanising iron articles. This product consists of zinc with from 4 to 6 per cent. of iron, but this percentage is very variable, and the results of its use, therefore, are in some cases unreliable. Probably metal made by this process was in use for some time for carriage bearings on the London & North Western and other railways, with very good results. It does not appear, however, to have ever been introduced for any purposes where the requirements were great strength, hardness and ductility.

Manganese Bronze.

The time, however, arrived, namely, in 1876, when these requirements were met by the aid of manganese in the manganese bronze of Mr. P. M. Parsons. This alloy is prepared by mixing a small proportion of ferro-manganese with copper. The ferro-manganese is melted in a separate crucible and is added to the copper when in the melted state. The manganese, in a metallic state, having a great affinity for oxygen, cleanses the copper of any oxides it may contain by combining with them and rising to the surface in the form of slag, which renders the metal dense and homogeneous. According to Mr. Parsons, a portion of the manganese is utilised in this manner, and the remainder with the iron becomes permanently combined with copper, and plays an important part in improving and modifying the quality of the bronze and brass alloys prepared from the copper thus treated. The effect is to increase greatly their strength, hardness and toughness, the degrees of all of which can be modified according to the quality of ferro-manganese used and the proportion of iron and manganese it contains. It will thus be seen that this method of making manganese bronze is altogether different both in principle and effect from the inventions of either Mr. Parks or Mr. Stirling.

Another point of importance is the nicety with which the iron and manganese can be adjusted, and their effect controlled by adding the ferro-manganese to the copper as pursued in the manufacture of manganese bronze. The amount of manganese required for deoxidising the copper and for permanent combination with it being well known by experience it is found that very slight variations in quantity have a perceptible and ascertained effect in modifying the qualities of the alloys produced, the toughness can be increased and the hardness diminished, or *vice versa* at will. In preparing the ferro-manganese for use, Mr. Parsons prefers that which is rich in manganese containing from 50 to 60 per cent. This is melted with a certain proportion of the best iron scrap so as to bring down the manganese to the various proportions required, at the same time any silicon it contains is reduced and the metal refined. About four qualities of ferro-manganese are made in practice, containing from about 10 to 40 per cent. metallic manganese. The author has been manufacturing manganese bronze for the last nineteen years under these principles, and has found them very successful. During the war many drop stampings were made. A great number of these alloys forge like mild steel, but care has to be taken not to overheat the bronze, for at high temperature it will powder away. About 500 deg. C. is the correct temperature for forging and stamping. Hot working and rolling improve these alloys considerably, and it is recommended where possible to forge the material.

Manganese-bronze castings should always be studied from a productive point of view, as only the most expert founder can be successful where these alloys are concerned. Standards of thicknesses should be kept as uniform as possible, for in the solidifying of these alloys great contraction takes place and cracks and segregation are not uncommon. Chilling methods have great and beneficial effect as far as sand castings are concerned, but these have to be carefully thought out. When casting, all gates should be immediately choked or filled to ensure clean castings; oxide or dross forms very rapidly when the metal comes in contact with the sand. The inlet gate should never exceed $\frac{3}{8}$ in. in diameter, and a skim gate provided as an inlet to the casting, which will counteract the dross going into the casting with the first drop of metal. Head pressure varies with weight of casting. In the manufacture of these particular alloys great care has to be exercised in the melting. It is the author's practice to make a ton at a time and remelt the ingots. This process gives the founder a fair idea of both composition and structure. If in the remelting overheating takes place the zinc will oxidise freely, which will have a serious effect on the strength of the alloy. Alloys of this group should never be heated above 1,060 deg. C. and cast around 960 deg. C. Castings made under

conditions outlined are homogeneous after machining. Castings up to 5 cwts. have been made in green sand successfully under personal directions. Some of the most successful main-line locomotives are running at the present time with manganese-bronze bearings weighing 4½ cwts. each, and manufactured by the North British Locomotive Company, Glasgow. (Fig. 2.) These bearings stand considerable wear and pounding, which is one of the greatest virtues of manganese-bronze bearings for axle-boxes.

Metallic packing should at no time be cast in sand moulds. The reason for this assertion is that being cast in sand moulds it takes too long to arrive at the freezing point, with the result that the denser metal separates from the lighter alloy, and uneven distribution is clearly shown. In the system of chilling a uniform structure throughout is got with no separation, a closer grain is obtained and all the particules are closely united, freezing point in many cases being instantaneous, which is one of the vital points in counteracting the separation of the different metals which are used in its manufacture.

White Metal for Bearing Purposes.

The metals used for the compositions of the various alloys are copper, tin, lead, zinc and antimony, but seldom more than three of these are used in any alloy. With machinery running at high speeds or with great pressure, the bearing surfaces are subjected to considerable friction, and in many cases the object of the engineer is rather to reduce this friction to the lowest degree than provide a bearing which will stand greater pressure without wearing. The common practice at the present time is to make the foundation of brass or of bronze, and to line the bearing surfaces with a renewable lining of white metal. One great advantage of white-metal alloys is their low melting point. A worn-out bearing can be readily melted out and replaced by a new one. Care should be exercised not to raise the metal to too high a temperature, as it causes the constituent metals to oxidise unequally, the volatile metals escape, and thus the composition is considerably altered. White-metal bearings are indispensable for certain purposes, for example, where the shaft in the bearing does not run smoothly. If the bearing is made of hard metal, considerable friction is set up, and a struggle will take place between the axle and the bearing, the softer of the two being worn away, causing the axle to be pitted or corded. By the use of a soft white-metal lining the axle is not worn, but it adapts itself to the condition of the bearing and runs with much less friction. Great diversity of opinion regarding high-tin alloys and high-lead alloys exists, but a great deal depends on the load which the bearing has to carry. This proves the usefulness of the alloys. For example, the truck axle-box bushes of the first Atlantic engines were lined with a high-tin alloy, and these bearings had to carry a heavy load. They gave considerable trouble at first until a high-lead bearing was substituted, and to the present day they are running on high-lead bearings. Zinc alloys of white metals have been very common, but they seem to have been discarded of late. They stand much heating, but this is at the expense of the axle, which in many cases becomes corded, and the axle has been known to give way in consequence. Some of these bearings actually have to be cut off the axle. When they become hot they do not fuse like a high-tin or a high-lead white metal and run out, but become a black mass of oil and grit and decomposed metal. Therefore engineers through practice can adopt the alloys most suitable for their requirements.

The man who aspires to the formation of new alloys or wishes to produce metals suitable for different requirements as circumstances arise must be well acquainted with the nature and properties of the simple metals in order to accomplish his object successfully, and although a knowledge of the components is not sufficient in itself, it is of advantage in assisting the operator who combines practical experience with theoretical knowledge in the mixing of metals.

Foundry Furnaces.

Furnaces, like a great many other parts of foundry equipment, have undergone considerable change, but still the author does not consider the tilting furnace an advantage in any way compared with a good hearth crucible furnace. The only improved furnace type from which consistent results may be expected—as regard melting and suitability—for the casting of high tin and gun-metal alloys will be the electrical furnaces, a goodly number of which are working in America where electrical power is cheap. The advantages to be gained from electrical melting are:—(1) Practical and desired temperatures can be obtained; (2) temperature can be controlled with accuracy; (3) introduction of impurities with fuel avoided; and (4) oxygen is not necessary in the furnace.

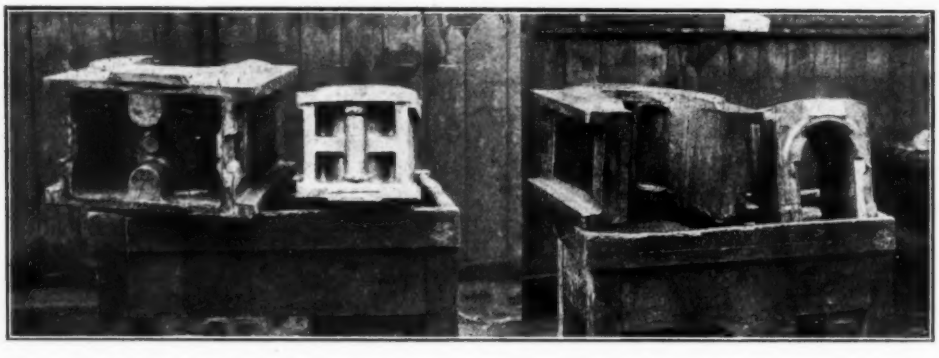


Fig. 2.—Manganese Bronze Axle-boxes made for the Southern Railway, showing Unequal Section.

The drawback in installing electrical furnaces is their initial cost and the high cost of electricity. Until electric power becomes cheaper the progress of this class of furnace will be hampered, but they will, it is thought, supersede all other types of furnace. In the manufacture of non-ferrous material much depends on the way it has been handled in the furnace. This is where a great deal of trouble lies, and without the aid and skill of highly-trained furnacemen who thoroughly understand the melting of the various metals one can anticipate failure and loss. Metal should at no time lie for a prolonged period when molten; as oxidation takes place very often and variation of composition is the result.

The furnaces (Fig. 3) are natural draught and consist of a battery of twelve furnaces. They are built from the best refractory materials which must be able to withstand violent fluctuations of temperature. They melt steel, iron and manganese with little or no trouble. A crucible of alloy containing 240 lbs. from a copper base can be melted and ready for casting in 1 hr. 10 mins., with a consumption of 56 lbs. coke. By 240 lbs. of metal is not meant yellow brass but gun-metal. Copper only is melted in furnaces as the author prefers to do all mixing for gun-metals, phosphor-bronze, etc., on the hearth. When the foundry is in full working order the

first six furnaces give five heats per day with no less melting capacity than 240 lbs. per heat, the others giving four heats per day.

Fig. 4 shows one of two reverberatory furnaces where is refined all copper scrap from boiler fire-box plates, copper stays, etc. It is lined with the best Glenboig brick. These furnaces use forced draught with a small coal box for manufacturing gas. The gas passes over the bridge and is ignited with hot air which melts the metal; its capacity is one ton. Two heats are taken from this furnace in 4 hrs., which includes charging and pouring into ingot moulds. All manganese bronze alloys are made in these furnaces with very successful results. The coal consumption per heat figures out about 4 cwts. 1 qr. to 17.5 cwts. of metal melted. The fuel used for these furnaces is "Baird's best hard coke." It may be a little dearer to begin with but is economical. No crusting or slagging round the bottom of the crucibles or furnaces as in the case of some brands of coke. Soft char is unsuitable for this class of work. Coal is used for the reverberatory furnace, and whilst splint is preferred, any class will do if carefully handled.

Quality of the Casting.

In every-day foundry practice castings are either rejected or accepted on the showing of the tensile strengths and elongations of definite

Fig. 3.—Crucible Melting Plant at the North British Locomotive Company, Limited, Glasgow.

test-pieces from the castings produced. While this may be a valuable check against the acceptance of faulty or inferior workmanship, yet the microscope reveals unmistakably that the cause of the trouble in many cases is entirely due to irregular sections in the casting. The evolution of the test-piece has been purely academic, and it can be demonstrated that in modern foundry practice no criterion exists of what a practical man would call a good job and suitable in every respect for their parts as engineering components.

Test results arrived at in laboratories from test-pieces cast in small sections, say 6 in. long by $\frac{5}{8}$ in. square, and, according to specified tests, may, in every respect, be acceptable, but if a test-piece is cut from a section of the same cast of material out of a casting bearing from $1\frac{1}{2}$ in. square to 8 in. square, it fails miserably under test without exception. These are the conditions modern foundrymen are subjected to. This is not quite in accordance with what metallurgists and consulting engineers would have us believe, although quite explainable by the foundryman.

If a sample of a gun-metal or high tin alloy consists of seven different sections, as detailed in Table I, A is in fine condition, the Alpha and Delta being very evenly distributed, and fairly homogeneous; B is also in fine condition, but a little coarser in structure, whilst C, D, and E are progressively still coarser, whilst F is very coarse in structure. In this type of structure there are local cavities. The seventh specimen G shows a 6 in. by $1\frac{1}{4}$ in. piece, cast under chilled conditions from the same mix of metal, showing the most homogeneous structure.

The test results are as follow:—

Table I.—*Properties of Gun-metal Test-pieces of increasing Section—Casting Temperature of Samples, 1,170 deg. Cent.*

Section.	Sand Cast.	Dia.	M.S. tons per sq. in.	E. per cent.	R.A. per cent.
A	$\frac{5}{8}$″ sq. × 6″ long	0.564	17.0	5.2	4.96
B	1″ sq. × 6″ ,,	0.798	14.5	4.8	4.44
C	$1\frac{1}{4}$″ sq. × 6″ ,,	0.798	13.8	3.5	3.2
D	2″ sq. × 6″ ,,	0.798	10.3	2.6	Nil
E	3″ sq. × 6″ ,,	0.798	9.0	2.0	Nil
F	4″ sq. × 6″ ,,	0.798	8.12	2.0	Nil
G	$1\frac{1}{4}$″ sq. × Chilled	0.798	17.4	1.75	1.96

All made from Virgin Metal—Copper, 85.5; Tin, 13.25; Zinc, 1.25.

The specimens are not the finest one can produce, but just what any foundry foreman gets every day if he cares to examine his product of such dimensions. It is, therefore, up to the consulting engineer, the designer, and the metallurgist to consider this problem, for the foundryman can only chill his castings to a very limited extent if the heavy sections of casting have to be anything like the small sections in structure and test requirements.

Table II relates to phosphor bronze for bearings and shows their properties, both sand and chilled cast.

Fig. 4.—Part of the Reverbatory Furnace Plant at the North British Locomotive Company, Limited, Glasgow.

Table II.—*Properties of Phosphor Bronze containing 80 Copper, 10 Tin, 8.0 Lead, and 2° Phos. Copper (Phos. 15%).*

Tests.	How Cast and dimensions.	Dia.	M.S. tons per sq. in.	E. per cent.	R.A. per cent.
1	Sand $\frac{5}{8}$″ sq. by 6″ long	0.564	14.48	6.0	4.96
2	Sand $1\frac{1}{4}$″ sq. by 6″ long		12.8	5.5	4.44
3	Chills $1\frac{1}{4}$″ sq. by 6″ long ..		18.6	7.3	9.28
4	Chills* $1\frac{1}{4}$″ sq. by 6″ long ..		22.24	7.0	broke outside centres.

* Sample No. 4 was free from lead.

In the consideration of these investigations the difficulties encountered in modern foundry practices are apparent in order to obtain the 100 per cent. results so much desired in modern marine and locomotive castings. As far as it is humanly possible a good sound job is assured by co-operation between the foundry and the laboratory, and the care exercised by the former finds confirmation in the results of tests carried out in the laboratories and test-rooms.

Many instances could be cited where demands are made on the material never contemplated from the foundry end, and sooner or later failure is reported. These failures, then, can hardly be attributed to the founder or the metallurgist.

XUM

Iron and Steel Institute.

Programme of Annual Meeting.

The annual meeting of the Institute will be held at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, May 6 and 7, 1926, commencing each day at 10 a.m. The following is the programme of proceedings:—

Thursday, May 6.—The Council and the Hon. Treasurer will present their annual reports for 1925. The new members will be elected. The newly-elected President (Sir W. Peter Rylands) will be inducted into the chair. The Bessemer gold medal will be presented to Sir Hugh Bell, Bt., C.B., and the President will deliver his presidential address.

A selection of Papers (Nos. 1, 6 and 15) will be read and discussed, the meeting adjourning at 1 p.m.

At the afternoon session (2.30 p.m.) the discussion of the morning's Papers will be continued, and if time permits Paper No. 5 will be read and discusssed.

Friday, May 7.—The award of the Andrew Carnegie Research Scholarships for 1926-7 will be announced, and a selection of Papers (Nos. 2, 8, 13 and 16) will be read and discussed, the meeting adjourning at 1 p.m.

At the afternoon session, Papers No. 14 and 11 will be read and discussed, and if time should not permit of the reading and discussion of Papers Nos. 3, 4, 7, 9, 10 and 12, they will be taken as read and discussion by correspondence will be invited.

Papers.

(1) Report on the Heterogeneity of Steel Ingots by a Sub-Committee of No. 5 Committee of the Institute; (2) "Coal Blending," by D. Brownlie; (3) "The Effects of Arsenic on Steel," by A. E. Cameron and G. B. Waterhouse; (4) "Specific Resistance and Thermo-electromotive Potential of some Steels differing only in Carbon Content," by E. D. Campbell and H. W. Mohr; (5) "Magnetic Changes in Iron and Steel below 400 deg. C.," by W. H. Dearden and C. Benedicks; (6) "A Note on the Distribution of Silicates in Steel Ingots," by J. H. S. Dickenson; (7) "The Ratio of the Tensile Strength of Steel to the Brinell Hardness Number," by R. H. Greaves and J. A. Jones; (8) "Notes on the 'Combustibility' of Coke and Direct Reduction in the Blast Furnace," by W. W. Hollings; (9) "Deformation Lines in Large and Small Crystals of Ferrite," by H. O'Neill; (10) "The Relation between the Lattice-Constant and Density of Iron-Nickel Alloys," by A. Osawa; (11) "The Hardening and Tempering of High-Speed Steel," by A. R. Page; (12) "The Estimation of Phosphorus in Steels containing Tungsten," by T. E. Rooney and L. M. Clark; (13) "Effect of Mass in the Heat Treatment of Nickel Steel," by W. Rosenhain, R. G. Batson and N. P. Tucker; (14) "The Hardness of Carbon Steels at High Temperatures," by I. G. Slater and T. H. Turner; (15) "Ghost Lines and Banded Structure of Rolled and Forged Mild Steels," by J. H. Whiteley; (16) "Influence of Segregation on the Corrosion of Boiler Tubes and Superheaters," by G. R. Woodvine and A. L. Roberts.

Annual Dinner.

The annual dinner will be held in the Grand Hall of the Connaught Rooms, Great Queen Street, W.C., on Thursday, May 6, at 7.15 for 7.30 p.m. Applications for tickets (price 12s. 6d. each, exclusive of wine), should be made not later than Thursday, April 29.

Autumn Meeting at Stockholm.

The autumn meeting will be held at Stockholm by the invitation of the Swedish Ironmasters' Association. The date of the meeting has now been fixed for August 26-28, and will be followed by visits to various ironworks and mines in the neighbourhood of Stockholm. Further particulars are given on the enclosed circular, and members who desire to attend are requested to return the reply form to the Secretary of the Institute as soon as possible.

For the reception of the members of the Institute an influential Committee, consisting of a large number of representatives of the Swedish Iron and Steel Industry, has been elected, and the following have been appointed to form an Executive Comittee for carrying out all the arrangements for the meeting:—Mr. E. Kinander, Director of Jernkontoret, chairman; Count G. von Rosen; Mr. A. Wahlberg; Mr. A. Herlenius; Mr. T. Wigelius; with Mr. A. Grabe as hon secretary. Subject to revision, the proposed programme of the meeting is as follows:—

Thursday, August 26.—A reception in the House of Jernkontoret in the evening, at which the General Reception Committee will welcome the President, members and ladies.

Friday August 27.—Morning meeting for reading and discussion of Papers. Arrangements will be made for visiting industrial enterprises in Stockholm in the afternoon. In the evening Jernkontoret will entertain their guests at dinner.

Saturday, August 28.—Morning meeting for reading and discussion of Papers.

Sunday, August 29.—Groups of members will leave Stockholm in the evening for the purpose of visiting ironworks and mines to the North and West of Stockholm.

Wednesday, September 1.—The groups will arrive in Stockholm or Gothenburg in the evening.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

The Cupola Furnace.

To the Editor of The Foundry Trade Journal.

Sir,—Certain points in my article on the cupola furnace which appeared in the issues of March 4 and 11 have been the subject of some criticism on the part of various correspondents. The most important point was raised by Mr. J. Shaw in connection with the melting temperatures quoted in the thermal balance-sheet. This point has been further amplified by Mr. Campion and Mr. F. D. Corbin in subsequent letters.

I regret the clerical error pointed out by Mr. Shaw, and the temperature should read 1,900 deg. C. I am unable to check this figure, as the figures of the investigation from which the balance-sheet was abstracted are not by me at the moment. I am also unable to check the temperature from the heat contents given, as I am unaware of the exact values of the thermal constants which were used in this investigation.

Apart from this, I am not so ready to admit that the figures I quoted are incorrect as Mr. Shaw supposes. I am familiar with the two investigations on the internal temperature of the cupola which are mentioned by Mr. Shaw as the only investigations "that are worth considering."

The Sulzer investigation carried out by Piwowarsky can be readily referred to by all foundrymen in the volume of The Foundry Trade Journal, August 13, 1925. In this investigation the temperatures and gas compositions were ascertained at different levels in the cupola, starting from a point above the tuyere level up to the charging level. These measuring points were numbered in this order, and if Mr. Shaw had read this carefully he would have found that no measurements are recorded for point (1), the first point of measurement at a level of 300 mms. from the tuyere level. The temperatures published in this investigation all start from point (2) at a level of 990 mms., over 3 ft. from the tuyere level. The temperatures obtained were plotted against the points of measurement. (See The Foundry Trade Journal, August 13, 1925, page 136.) One of these diagrams is reproduced below. The extension of this diagram down to point (1) can be added. By extrapolation in this manner it would appear that the actual temperature at point (1), 300 mms. from the tuyere level, closely approximates the temperature of 1,900 deg. C. quoted by me. On the grounds of comparison with one of "the only investigations worth considering," the temperature of 1,900 deg. C. does not necessarily appear to be "an absurd melting temperature."

Two of the points discussed by Mr. Roper in his letter in the issue of April 8 are undoubtedly inspired by my article. These points relate to the question of one row of tuyeres and the parallel lining of the cupola respectively.

The statement that there is no special merit in having more than one row of tuyeres if they pass the requisite amount of air, is by no means an incomplete one. This statement does not only refer to straightlined cupolas, but it refers to all cupolas.

The melting zone diagram referred to by Mr. Roper in my article is plotted from gas and temperature determinations from an actual cupola of 27-in. diameter. This cannot be considered a large diameter cupola, and any decrease in the diameter below this would have very little influence on the inverted cone formation of the melting zone.

If two cupolas melt the same amount of iron per hour the diameter at the tuyere level is practically the same, regardless of whether the lining is straight or restricted. In this case the restriction would take the form of a "flaring" of the cupola lining above the tuyere level. This flaring would have the tendency to produce the very conditions in the restricted lining type which Mr. Roper seeks to prove exist in the straight-lined type.

Yours, etc.

Sheffield, April 10. J. E. Hurst.

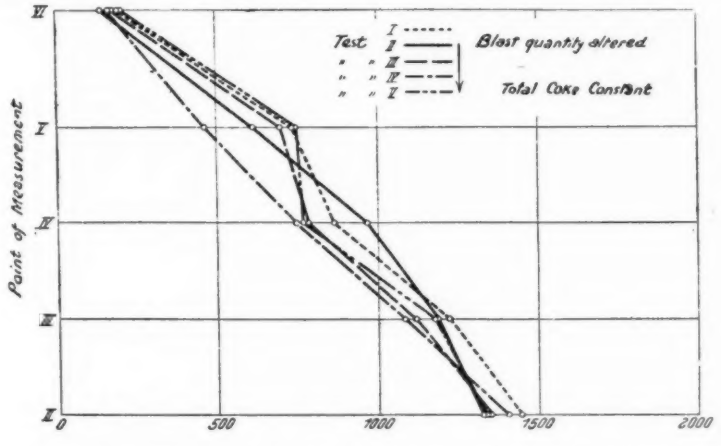


Fig. 4 of Piwowarsky and Meyer's Paper on "The Adjustment of the Cupola Furnace from the Point of View of Heat Economy, showing the Furnace Temperatures in Test Series No. 1."

Electric Furnace Practice.

To the Editor of The Foundry Trade Journal.

Sir,—With reference to the article by Mr. F. A. Melmoth on "Some Metallurgical Points in Electric Steel Castings and Notes on Defects," published in your issue of December 31, I was very interested in the point raised on "The effect of high temperature, together with a high silicon content."

This, surely, is more a question of bad furnace practice, and will nearly always take place if the scrap charged into the furnace is very rusty, causing a long melting period with very great local overheating from the arcs and producing badly over-oxidised low-carbon metal.

During this period the over-heating, together with the very rusty scrap, has caused such over-oxidation that ferro-silicon will not deoxidise the bath, even if up to 1 per cent. Si is added after slagging or during the second period.

I suggest that this prolonged melting period causes a "liquid burning" due to the metal just round the electrodes being "stewed" at the maximum temperature obtainable round the arc during a long period.

When the charge has melted cold and mild then, even after a considerable amount of current has been used to bring up the temperature, the bath will be cold after slagging, with a very great danger of burning the furnace, and this resulting in a high silicon content in the finished charge.

I quite agree with the author that the condition of the silicon content will be different from a normal steel, and I believe that this wildness is due to the "liquid burning," which causes the silicon to exist as some sub-oxide of silicon, probably combined with the iron and manganese.

The author stated that returning the liquid steel to the furnace and making a new lime slag did not have any beneficial effect, and the above theory will explain this.

I have only come across two such cases, and on each occasion the scrap charged was very rusty and the bath melted cold, but on "stewing" was brought to a high temperature for casting on addition of pig-iron and ferro-manganese, without, however, being killed by the usual additions of ferro-silicon.

In regard to the samples being sound, as stated by the author, I have found that samples taken in a spoon and poured into a small mould, say $2\frac{1}{2}$ in. × 2 in. × 3 in., and allowed to cool, will often appear quite "dead" when this is not actually the case.

I always take my samples in the following manner:—A spoon sample is poured into a 3-in. sq. mould about 7 in. deep, and as soon as it has "skinned over" I prick the skin with a small hot bar, say $\frac{3}{8}$ in., and successively prick through the skin as it has formed and until the metal solidifies; usually three prickings are sufficient to follow the piping down.

Very often a sample taken under the first condition appears "dead," but on taking in the second manner, just before the sample solidifies, it will rise possibly $\frac{1}{4}$ in., and appear in the form of a button, showing that the steel was not dead.

If the author had taken his samples in this manner he would have detected oxidation.

To sum up. The cure for this trouble is to use scrap sufficiently high in C and Mn to melt, say, not under C 0.15 per cent., or to add pig-iron and/or high manganese scrap to bring the charge up to normal melting conditions.

I have standardised my mixes, so that I can obtain a sample on melting with C 0.25 to 0.30 and Mn 0.35 to 0.50 per cent., using various grades of scrap and pig-iron to obtain this.

After slagging I can add ferro-silicon on the bath to finish within a limit of 0.06 per cent. in the finished charge, working with a hot furnace for charging.

As a point of interest, my "tapping" slags contain 15 to 20 per cent. SiO_2 and 55 to 60 per cent. CaO, and a spoon sample taken in a 5-in. dia. spoon taking 42 seconds to skin over will cast 7 tons during 40 minutes with a clean ladle, and produce *all* perfectly sound castings.—Yours, etc.,

G. M. G.

Stavanger.
April 3, 1926.

Trade Talk.

The last meeting of the session of the Sheffield Metallurgical Association was held last week, when a discussion on "Reactions in the Basic Electric Furnace" was opened by Mr. H. Etchells. Mr. T. G. Elliott presided.

Vickers, Limited, are reported to be acquiring an interest in the Commonwealth Steel Products, Limited, of Newcastle, New South Wales. Since the inception of this company Taylor Bros. & Company, Limited, Manchester, have been associated. Vickers-Commonwealth Steel Products, Limited, will pursue a progressive policy in the manufacture of railway wheels, tyres, and axles, steel castings, and forgings.

The Anglo-Saxon Petroleum Company, Limited, have placed with Harland & Wolff, Limited, orders for four motor-propelled vessels designed for the carriage of oil in bulk. The vessels, which will be constructed in their builders' Govan yard, will have Harland and Wolff-Burmeister and Wain engines from the same firm's Diesel Engine Works in Glasgow. One will be of 1,050 tons, one of 3,600 tons, and two of 2,300 tons each. The same owners have placed an order for an oil-carrying vessel with the Caledon Shipbuilding & Engineering Company, Limited, Dundee.

At a meeting held at Manchester recently, the proposed amalgamation between Mirrlees, Bickerton & Day, Limited, of Hazelgrove, Stockport, and the Mirrlees Watson Company, Limited, Glasgow, was confirmed. It was decided that the capital of the company be increased to £600,000 by the creation of 250,000 additional ordinary shares of £1 each. The following, in addition to the present directors, were elected directors of the company until the annual general meeting in 1927: Mr. Charles Ker, Mr. Andrew Lamberton, Mr. William Scott Herriot, and Mr. William Alinson Dexter.

At the annual meeting of the West of Scotland Iron and Steel Institute, held recently in the Royal Technical College, Glasgow, Mr. Edwin H. Lewis, the retiring president, said one of the most satisfactory features of the past session was the increase in the numbers attending the meetings, the average having been about one hundred. They had hoped that when the session closed trade would have improved, but it was still difficult to say what the future had in store, as there was a dark cloud in the form of a threat of trouble in the coal industry. They in the iron and steel trades depended absolutely on supplies of coal, but it would be unwise to say anything at that time about the Report of the Coal Commission, or to make any remarks in the way of criticism. He hoped that before the next session began there would be a real improvement in the iron and steel trades. Mr. D. A. MacCallum, the secretary, in submitting the annual report, said the membership of the Institute of 638—a slight increase on the year—and the funds at the close of the session amounted to £944—an increase of £24. Afterwards Mr. John Craig was elected president for the ensuing session.

Company Reports.

C. W. Walker & Company, Limited.—Dividend, 10 per cent. for year.

Bengal Iron Company, Limited.—No dividends on either ordinary or preference shares.

Beyer, Peacock & Company, Limited.—Preference dividend, 5½ per cent., actual, less tax.

English Electric Company, Limited.—Full preference dividend, but no dividend on ordinary shares.

Furness, Withy & Company, Limited.—Dividend on ordinary shares, 5 per cent. per annum for half-year ending April 30, free of tax; interim, 2½ per cent., paid in October.

Smith & McLean, Limited.—Net profit, £36,866; brought forward, £18,745; ordinary reserve fund, £20,000; dividend on ordinary shares, 7 per cent. per annum, less tax; carry forward, £19,537.

Lancashire Dynamo & Motor Company, Limited.—Profit, after providing £850 for depreciation and £2,064 for debenture interest, £20,201; brought in, £204; dividend, 7½ per cent.; reserve, £5,000; carried forward, £2,147.

A. Reyrolle & Company, Limited.—Profit, £70,620; brought forward, £19,705; available, £89,826; preference dividend, 7 per cent. per annum, £2,800; ordinary dividend, 12½ per cent. per annum, £42,154; reserve account, £15,000; carried forward, £29,872.

J. Stone & Company, Limited. — Net profit, £161,058; brought in, £135,057; reserve, £130,000; dividend, 2s. per share on ordinary shares; carried forward, £67,075. Sum of £200,133 taken from reserve and applied in repaying 6s. 8d. of amount paid up on ordinary shares, leaving them 13s. 4d. paid.

Obituary.

Mr. T. Shaw, of Wadsley Bridge, manager of the Saw Department of Thomas Firth & Sons, Limited, Norfolk Works, Sheffield, died recently.

Mr. W. Kirkham, governing director of the firm of William Kirkham, Limited, furnace builders, Wood Street, Sheffield, died recently, aged 68 years. He was formerly associated with William Jessop & Sons, Limited, and started on his own account in 1891.

Mr. Arthur Llewellyn Lloyd, of Calthorpe Road, Edgbaston, and chairman of Thos. Piggott & Company, Limited, Atlas Works, Spring Hill, Birmingham, whose death at the age of 70 occurred on March 28, was the third son of the late Mr. Sampson S. Lloyd, M.P. (for many years chairman of Lloyds Bank), and a first cousin of Alderman J. H. Lloyd. Born in Birmingham, Mr. Lloyd was educated at Uppingham, and afterwards spent some years at Middlesbrough, in the engineering works of Hopkins, Gilkes & Company. Subsequently, on the purchase by his father of the business of Thomas Piggott & Company, engineers, Spring Hill, Birmingham, he joined that firm, became a director, and was chairman for many years. He was also a director of The Mint (Birmingham), Limited, and New Hudson, Limited.

Herr August Thyssen, the principal of the well-known German firm of Thyssen & Company, and probably the greatest industrial magnate in the Ruhr, has died at the advanced age of 85. It was in the late 'sixties that Thyssen left his father's small forge at Eschweiler to join his brother in establishing a small rolling mill plant at Duisburg, under the name of Thyssen, Fossoul & Company. The firm, although starting in an exceedingly modest way, prospered with the outbreak of the Franco-Prussian war, and in about 4 years had acquired a property at Styrum for another works. This undertaking likewise prospered, and with the next 30 years the firm of Thyssen & Company was built up to its present enormous dimensions, with subsidiary concerns in all the allied industries. In 1903 Herr Thyssen made one of his rare incursions into the open to negotiate the amalgamation of the Gelsenkirchen, Schalke and Rote Erde undertakings, which became the nucleus of the great Gelsenkirchen organisation. After engineering this he turned his attention upon Lorraine. From German Lorraine he progressed into the iron basin of French Lorraine. In this direction the company's ramifications became enormous, extending to Caen, where they had their harbour; through the Saar and the Moselle; into cement, potash, lignite, and other trusts; electrical power in Rhenish Westphalia, and shipbuilding and shipping at Bremen. Notwithstanding these extensions, the parent firm remained a private concern, directed almost solely by Herr Thyssen. During the late war the firm was exceedingly busy and prospered greatly. In 1920 a long-standing dispute between Herr August and his son Fritz, who had set up as an industrialist independent of his father, was reported to have been brought to a conclusion. It will be remembered that Herr Fritz Thyssen was among the German industrialists tried by the French for refusing to deliver coal.

Dr. H. R. Wright, who succeeds the late Mr. Francis Hird as managing director of Siemens Brothers & Company, Limited, was born in 1877. From early days his father, Henry S. Wright, of London, who was connected with chemical works in Manchester and Widnes, encouraged him to make experiments in chemistry and physics. His serious engineering training commenced at the Regent Street Polytechnic, London, under Professor H. Spooner, and was continued at the Technical High Schools at Munich and Karlsruhe, under Arnold, and at the University of Munich, where he took his Doctor's degree at the early age of 21. Before returning to England, he acquired practical knowledge of Continental dynamo design at Vienna under the well-known Austrian designer, the late Professor Pichelmayer, and then obtained an appointment with Siemens Brothers & Company, Limited, at Stafford. When the company decided to interest themselves in the field of telephony and to extend their works at Woolwich, he joined, in October, 1907, the new organisation at the request of his former chief, Mr. F. Hird, at one time works manager of the Stafford Works of Siemens Brothers Dynamo Works, Limited, and who had taken charge at Woolwich of this new work. During the 24 years of his service with the Siemens' undertakings he has been sucessively concerned with the activities of nearly every one of the departments, from designing large generator units to the introduction of mass production of small dry cells. During later years he was drawn more and more on to the administrative side, and in 1925 was appointed general manager to the company.

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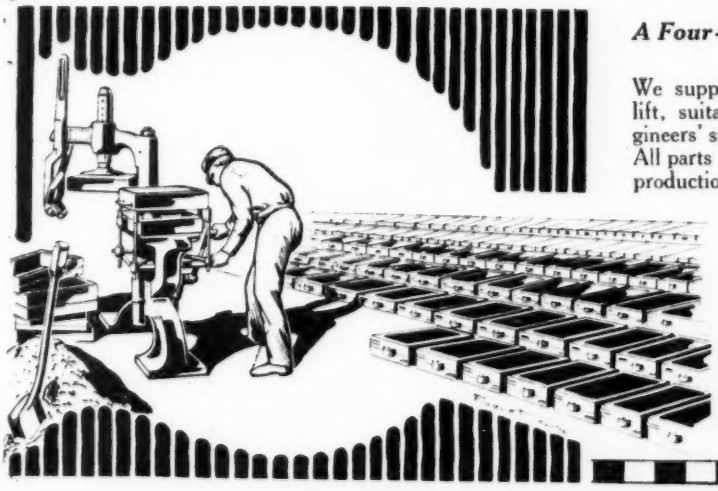

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IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—In view of the very uncertain aspect of affairs in the industrial disturbance looming in the immediate future, it is not surprising that the resumption of Cleveland iron market last week again indicated only a small measure of interest in actual business of selling and buying, with the bulk of transactions strictly limited to the most pressing requirements. Pending more satisfactory conditions, forward buying to any extent is regarded as a hopeless expectation, while makers, on the other hand, are by no means anxious to close future commitments while the fuel problem is still in abeyance. Should, however, the miners' trouble be overcome within a reasonable period, new considerations will arise. Producers by that time will have come into the market, and prices will probably reach a level more consonant with consumers' ideas. A slight improvement in Tees-side exports has to be recorded, shipments of pig-iron from the port of Middlesbrough and Skinningrove during March having amounted to 35,955 tons, as compared with 34,266 tons in February, an increase of 1,689 tons. However, prices in the meantime are held unchanged, No. 1 being 73s., No. 3 G.M.B. 70s. 6d., No. 4 foundry 69s. 6d., and No. 4 forge 68s. 6d. per ton. These are export figures, home prices being 6d. per ton less.

The position in the hematite market on Tees-side continues quiet, and makers are only getting 76s. per ton for East Coast mixed numbers, and to 76s. 6d. per ton for the No. 1 quality. But these prices would no doubt be shaded for any attractive offer. On the North-West Coast, prices are:—Bessemer mixed numbers, £4 1s. 6d. to £4 2s. 6d., c.i.f. Welsh ports, £4 5s. 6d. to £4 7s. 6d. per ton delivered at Glasgow, £4 8s. to £4 10s. per ton delivered at Sheffield, and £4 12s. to £4 14s. per ton delivered at Birmingham.

LANCASHIRE.—Current transactions in the local markets for foundry iron are only in limited volume, many large consumers being already covered by contracts entered into several months ago. Quotations are, however, quite steady, and makers are offering no encouragement to those users who are looking for concessions. Derbyshire No. 3 pig ranges from 75s. to 76s. 6d. per ton, according to make, for delivery Manchester or equal, while Staffordshire and Lincolnshire are round 76s. per ton, with Scottish No. 3 at 94s.

THE MIDLANDS.—A steadier tendency in foundry pig business is reported in this area, but business on any scale of importance is evidently being held up until this week's quarterly meeting to-day (Thursday). In the meantime prices remain at about previous quotations, as follow:—Derbyshire No. 3 foundry, 67s. 6d.; Staffordshire No. 3 foundry, 67s. 6d.; Northants. No. 3 foundry, 63s. to 63s. 6d.

SCOTLAND.—New business in foundry pig continues practically at a standstill both at Glasgow and Falkirk, pending a settlement of outstanding labour difficulties, consumers only making hand-to-mouth purchases. With such a market, prices are unchanged at 76s. 6d. for No. 3 Scotch foundry at the furnaces, and whilst traders are inclined to think that prices are about as low as can be expected, they have not the courage to come into the market and buy round parcels.

Finished Iron.

Manufacturers of this class of material throughout the country report extremely unsatisfactory conditions of trade, works' order books, in the majority of cases, being short of specifications, and in many instances plants are only operating partial time.

Scrap.

Buying in all sections of the scrap material markets continues on a restricted scale, while in Scotland the position of heavy machinery cast-iron scrap is, if anything, a little weaker, there being little or no demand from the foundries. Some odd lots have changed hands around 73s. 6d. to 74s. per ton, and for ordinary heavy cast-iron scrap to the same specification, suitable for foundries, about 5s. per ton less. Old cast-iron railway chairs are still being offered at 73s. 6d. per ton, but orders for this class of material are very scarce. Light cast-iron and firebars are still around 61s. to 62s. per ton. The above prices are all per ton, delivered, f.o.t. consumers' works. In Lancashire there is only a moderate demand for ordinary machinery scrap at about 70s. per ton, while textile quality is quoted at 72s. 6d., both delivered consumers' works.

Metals.

Copper.—Influenced largely by the continued weakness of recent American advices, values of standard copper have further declined, with but few signs of an early recovery to higher levels. The heavy stocks held in this country are also a drag upon the market, whilst the policy of hand-to-mouth buying, from which consumers here show no disposition to depart, exercises a depressing influence. Even at the reduced level of values, the manufacturing trades have not shown the slightest inclination to cover potential requirements. Current quotations:—*Cash*: Thursday, £57; Friday, £56 15s.; Monday, £56 15s.; Tuesday, £56 17s. 6d.; Wednesday, £57 12s. 6d.

Three Months: Thursday, £57 17s. 6d.; Friday, £57 12s. 6d.; Monday, £57 12s. 6d.; Tuesday, £57 15s.; Wednesday, £58 10s.

Tin.—Consequent upon the issue of the official report early in the month, the tendency of tin values has inclined to firmer figures, based upon a more favourable statistical position, which may be summarised as follows:—The total decrease in the visible supply of 1,840 tons amounts to the low record of 13,597 tons. The Straits shipments, as expected, were very small, totalling only 3,920 tons for Europe and the United States, while 337 tons were absorbed by Far Eastern ports. Good contributions were made from Java, which, together with other supplies, made the aggregate for March 8,036 tons, against which the total deliveries amounted to 9,876 tons. Current quotations:—*Cash*: Thursday, £279; Friday, £279 10s.; Monday, £280; Tuesday, £284 5s.; Wednesday, £286.

Three Months: Thursday, £267; Friday, £268; Monday, £269; Tuesday, £270 5s.; Wednesday, £273 5s.

Spelter.—Of this section of the market, a trade authority writes:—"The market is showing a good deal of resistance to further fall, for it is generally considered that the decline which has taken place since the beginning of the year has gone far enough; the price, in all the circumstances, may be regarded as reasonably cheap, and offers little attraction to sellers. On the whole, a slightly better demand is reported from consumers, both in this country and on the Continent, and the latter is not pressing metal for sale. Current quotations:—*Ordinary*: Thursday, £32 6s. 3d.; Friday, £32 7s. 6d.; Monday, £32 1s. 3d.; Tuesday, £32 11s. 3d.; Wednesday, £32 16s. 3d.

Lead.—The market for soft foreign pig is again uneventful, consumers being apparently indifferent to the attraction of lower values for the time being. Rudolf Wolff say that lead has been, on the whole, rather steadier, there being little or no change, operators displaying less anxiety to sell at the current level of prices. At the same time, slightly improved demand is reported from the Continent. Current quotations:—*Soft foreign (prompt)*: Thursday, £29; Friday, £28; Monday, £28 7s. 6d.; Tuesday, £29; Wednesday, £29 2s. 6d.

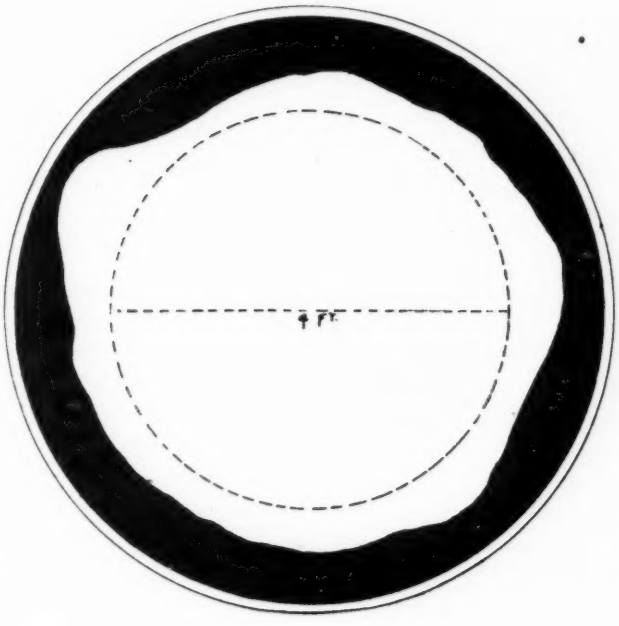
Institute of Metals.

Autumn Meeting at Liege.

The autumn meeting of the Institute of Metals is to be held at Liége from September 1 to September 4, the hosts being the Association des Ingenieurs Sortis de l'Ecole de Liége. Dr. W. Rosenhain, F.R.S., is to deliver the autumn lecture on the evening of September 1. The mornings of September 2 and 3 will be taken up with the reading and discussion of papers, whilst the afternoons of these days will be devoted to works visits. There is to be a civic reception on the Thursday evening (September 2) and a smoking concert the following evening. On Saturday, September 5, there is to be an all-day excursion.

Obituary.

We regret to announce the death of Mr. Michael Simm, the senior partner in the firm of Martha Simm & Sons, at the age of 88 years. He was probably the oldest manufacturer of foundry blackings and charcoal in the country. He entered the business at the age of 17 years on the death of his father, the late John Simm, in 1855, and carried it on in conjunction with his mother, the late Martha Simm, until her retirement. He was well known to the older generation of foundrymen in the North of England and was attending to business until two days before his death.



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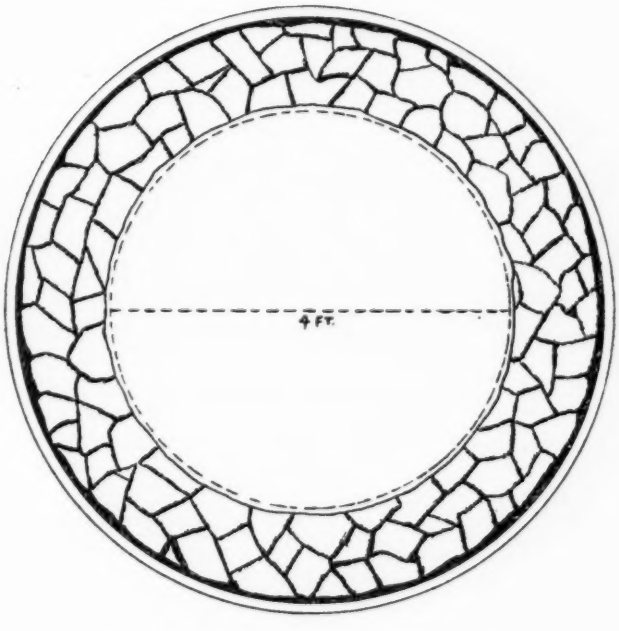

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WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash ..	57	12	6
Three months ..	58	10	0
Electrolytic	64	10	0
Tough	59	10	0
Best selected ..	60	0	0
Sheets	90	0	0
India	74	0	0
Wire bars	64	10	0
Do. April	64	5	0
Do. May	64	5	0
Ingot bars	64	5	0
H.C. wire rods ..	68	10	0
Off. av. cash, Mar..	58	13	3 15/23
Do., 3 mths. Mar.	59	12	5 9/23
Do., Sttlmnt, Mar.	58	13	0 11/23
Do., Electro, Mar.	65	13	7 1/23
Do., B.S., Mar. ..	62	10	3½
Aver. spot price copper, Mar. ..	58	13	0½
Do., wire bars, Mar.	65	17	4½
Solid drawn tubes			13d.
Brazed tubes ..			13d.
Wire			9¾d.

BRASS.

Solid drawn tubes ..	12d.
Brazed tubes	13½d.
Rods, drawn	10¾d.
Rods, extd. or rlld. ..	7½d.
Sheets to 10 w.g ..	10½d.
Wire	9¾d.
Rolled metal	9½d.
Yellow metal rods ..	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets ..	8½d.

TIN.

	£	s.	d.
Standard cash ..	286	0	0
Three months ..	273	5	0
English	284	5	0
Bars	284	15	0
Straits	289	5	0
Australian	285	0	0
Eastern	277	0	0
Banca	284	10	0
Off.aver. cash, Mar.	292	8	6 9/23
Do., 3 mths.,Mar.	283	12	11 21/23
Do., Sttlmt. Mar.	292	8	5 11/23
Aver. spot., Mar.	292	8	6½

SPELTER.

	£	s.	d.
Ordinary	32	16	3
Remelted	33	0	0
Hard	27	0	0
Electro 99.9 ..	36	0	0
English	33	5	0
India	29	2	6
Zinc dust	42	0	0
Zinc ashes	14	0	0
Off. aver., Mar. ..	34	3	4 10/23
Aver., spot, Mar.	34	1	9½

LEAD.

	£	s.	d.
Soft foreign ppt.	29	2	6
English	30	10	0
Off. average, Mar.	31	15	5 5/46
Average spot, Mar.	31	12	6

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	41	0	0
Do. V.M. ex whf.	39	10	0
Rods	44	0	0
Boiler plates ..	39	10	0
Battery plates ..	39	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	89	10	0
Chinese	79	0	0
Crude	50	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver ..	13	17	6

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Ferro-silicon	
25%	9 10 0
45/50%	11 10 0
75%	20 10 0
Ferro-vanadium—	
35/40%	14/5 lb. va.
Ferro-molybdenum—	
70/75% c. free	6/- lb.
Ferro-titanium—	
23/25% carbonless	11½d. lb.
Ferro-phosphorus, 20/25%,	£17 0 0
Ferro-tungsten—	
80/85%,c.fr. ..	1/9½ lb.
Tungsten metal powder—	
98/99%	2/1 lb.
Ferro-chrome—	
2/4% car. ..	£35 0 0
4/6% car. ..	£22 7 6
6/8% car. ..	£21 15 0
8/10% car. ..	£20 17 6
Ferro-chrome—	
Max. 2% car.	£38 10 0
Max. 1% car.	£44 10 0
Max.0.70%car.	£54 10 0
70%,carbonless	1/5½ lb.
Nickel—99%, cubes or pellets ..	£170
Cobalt metal—98/99%	10/- lb.
Aluminium 98/99%	£112
Metallic Chromium—	
96/98% ..	3/3 lb.
Ferro-manganese (net)—	
76/80%, loose	£15 0 0
76/80%, packed	£16 0 0
76/80%, export	£14 5 0
Metallic manganese—	
94/96%, carbonless	2/- lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten ..	2	6
Finished bars, 18% tungsten ..	3	0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. and over ..	4d.lb.
Rounds and squares under ½ in. to ¼ in.	3d. lb.
Do. under ¼in. to ⅛ in.	1/- lb.
Flats, ½in. × ½in. to under 1 in. × ⅛ in.	3d. lb.
Do. under ½in. × ½in.	1/- lb
Bevels of approved sizes and sections	6d. lb.
Bars cut to length	10%extra
Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/s steel makers' work

SCRAP.

South Wales—Hvy. steel	£ 3 8 6	to £ 3 12 6	
Bundled steel & shrngs.	3 3 6	to 3 7 6	
Mixed iron & steel	3 2 6	to 3 5 0	
Heavy cast iron	3 2 6	to 3 6 0	
Good machinery for foundries ..	3 7 6		
Cleveland—			
Heavy steel ..	3 5 0		
Steel turnings ..	2 7 6		
Cast iron borings	2 5 0		
Heavy forge ..	4 5 0		
Bushelled scrap	3 10 0		
Cast-iron scrap	3 7 6		
Lancashire—			
Cast-iron scrap	3 10 to 3 15 0		
Hvy. wrought ..	3 5 0		
Steel turnings ..	2 2 0		

London — Merchants' buying prices delivered yard.

Copper (clean)..	48	0	0
Brass (clean) ..	38	0	0
Lead (less usual draft)	26	10	0
Tea lead ..	22	10	0
Zinc	23	0	0
New aluminium cuttings ..	78	0	0
Braziery copper	43	0	0
Gunmetal ..	44	0	0
Hollow pewter	180	0	0
Shaped black pewter ..	132	0	0

PIG-IRON.

(*f.o.t. unless otherwise stated*).

N.E. Coast—	
Foundry No. 1 ..	72/6
Foundry No. 3 ..	70/-
Foundry No. 4 ..	69/-
Forge No. 4	68/-
Hematite No. 1 ..	76/6
Hematite M/Nos. ..	76/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	86/6
,, d/d Birm.	93/-
Midlands—	
Staffs common* ..	—
,, No. 4 forge ..	62/6
,, No. 3 foundry	67/-
Shrops. basic	70/-
,, Cold blast, ord.*	185/-
,, ,, roll iron* ..	190/-
* d/d Birmingham.	
Northants forge	56/6
,, fdry No. 3 ..	63/3
Derbyshire forge ..	60/6
,, fdry. No. 3 ..	67/6
,, basic	65/-
Scotland—	
Foundry No. 1 ..	81/6
,, No. 3 ..	76/6
Hem. M/Nos.	76/6
Sheffield (d/d district)—	
Derby forge	65/-
,, fdry. No. 3 ..	71/6
Lincs. forge	67/6
,, fdry. No. 3 ..	70/-
E.C. hematite	87/-
W.C. hematite ..	89/-
Lincs. (at furnaces)—	
Forge No. 4	61/6
Foundry No. 3.. ..	64/-
Basic	63/-
Lancashire (d/d eq. Man.)—	
Derby forge	68/-
,, fdry. No. 3 ..	75/6
Northants foundry No. 3	76/-
Dalzell, No. 3	110/-
Summerlee, No. 3 ..	94/-
Glengarnock, No. 3 ..	94/-
Gartsherrie, No. 3 ..	94/-
Monkland No. 3	94/-
Coltness, No. 3	94/-
Shotts, No. 3	94/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.	£ s. d.
Bars(cr.)	11 0 0 to 12 0 0	
Angles	11 10 0	
Tees to 3 united ins.	12 0 0	
Nut and bolt	10 5 0 to 10 7 6	
Hoops	14 0 0 to 15 0 0	
Marked bars (Staffs.) f.o.t. ..	14 0 0	
Gas strip	12 10 0	
Bolts and nuts .. ¾ in. × 4 in. ..	15 5 0	
Steel—		
Ship plates	7 10 0 to 7 15 0	
Boiler plts. ..	11 5 0	
Chequer plts. ..	9 15 0	
Angles	£7 0 0 to 7 5 0	
Tees	£8 0 0 to 8 5 0	
Joists	£7 0 0 to 7 5 0	
Rounds and Squares 3 in. to 5½ ins. ..	7 15 0	
Rounds under 3 in. to ⅜ in.	7 10 0	
Flats, over 5 in. wide and up ..	8 5 0	
Flats, 5in. to 1½in.	7 5 0	
Rails, heavy ..	8 0 0	
Fishplates	12 0 0	
Hoops (Staffs.) ..	10 10 0	
Black sheets, 24g.	11 5 0	
Galv. cor. sheets, 24g.	15 15 0 to 16 0 0	
Galv. fencing wire 8g. plain	14 0 0	
Billets,soft	£6 2 6 to 6 5 0	
Billets, hard ..	8 2 6	
Sheet bars	6 0 0 to 6 2 6	
Tin bars d/d	6 2 6 to 6 5 0	

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	3
Sheet to w.g.	1	3½
Wire	1	3½
Rods	1	3
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free

10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks ..	9d. to 1/5½
Ingots rolled to spoon size ..	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	23.26
No. 2 foundry, Valley	22.26
No. 2 foundry, Birm.	22.00
Basic	21.76
Bessemer	22.76
Malleable	22.26
Grey forge	21.76
Ferro-mang. 80% d/d	88.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	35.00
O.-h. billets	35.00
O.-h. sheet bars ..	36.00
Wire rods	45.00
	Cents.
Iron bars, Phila. ..	2.22
Steel bars	2.00
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel ..	1.90
Skelp, sheared steel ..	1.90
Steel hoops	2.80
Sheets, black, No. 28..	3.25
Sheets, galv., No. 28 ..	4.50
Sheets, blue an'l'd, 9 & 10	2.50
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv. ..	3.35
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry ..	32/6 to 37/6
,, furnace ..	20/- to 25/-
Durham & North.	
,, foundry	30/- to 33/-
,, furnace ..	15/-
Other Districts, foundry	30/- to 33/-
,, ,, furnace (basis)	11/9

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes, 20×14, box		19/4½
,,	28×20, ,,	38/9
,,	20×10, ,,	29/1½
,,	18¾×14, ,,	20/4½
C.W.	20×14, ,,	17/7½
,,	28×20, ,,	35/1½
,,	20×10, ,,	24/1½
,,	18¾×14, ,,	18/4½

Terneplates 28×20, 35/9 per box basis f.o.b.

SWEDISH IRON.

Bars,hammered	£18/10 to £19/0
Rolled Ord.	£15/15/0 to£16/5/0
Nail rods	£16 5 0 to £16 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£9 to £12

Pig-iron £6 5 0 to £7 0 0 all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes	*Fittings*
Gas ..	60%	.. 50%
Water ..	55%	.. 45%
Steam ..	50%	.. 40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.		
Apr. 8	57	0	0	dec.	10/-
,, 9	56	15	0	,,	5/-
,, 12	56	15	0	No change	
,, 13	56	17	6	inc.	2/6
,, 14	57	12	6	dec.	5/-

Electrolytic Copper.

	£	s.	d.		
Apr. 8	64	10	0	dec.	5/-
,, 9	64	5	0	,,	5/-
,, 12	64	0	0	,,	5/-
,, 13	64	5	0	inc.	5/-
,, 14	64	10	0	,,	5/-

Standard Tin (Cash).

	£	s.	d.		
Apr. 8	279	0	0	dec.	120/-
,, 9	279	10	0	inc.	10/-
,, 12	280	0	0	,,	10/-
,, 13	284	5	0	,,	85/-
,, 14	286	0	0	,,	35/-

Tin (English ingots).

	£	s.	d.		
Apr. 8	277	10	0	dec.	115/-
,, 9	278	0	0	inc	10/-
,, 12	278	10	0	,,	10/-
,, 13	283	15	0	,,	105/-
,, 14	284	5	0	,,	10/-

Zinc Sheets (English).

	£	s.	d.		
Apr. 8	41	0	0	No change	
,, 9	41	0	0	,,	,,
,, 12	41	0	0	,,	,,
,, 13	41	0	0	,,	,,
,, 14	41	0	0	,,	,,

Spelter (ordinary).

	£	s.	d.		
Apr. 8	32	6	3	dec.	18/9
,, 9	32	7	6	inc.	1/3
,, 12	32	1	3	dec.	6/3
,, 13	32	11	3	inc.	10/-
,, 14	32	16	3	,,	5/-

Lead (English).

	£	s.	d.		
Apr. 8	30	15	0	dec.	10/-
,, 9	30	0	0	,,	15/-
,, 12	30	0	0	No change	
,, 13	30	10	0	inc.	10/-
,, 14	30	10	0	No change	

AVERAGE MONTHLY PRICES OF STEEL SHIP ANGLES (NORTH OF ENGLAND).

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	4 15 0	4 17 6	5 0 0	5 0 0	5 0 0	4 17 6	4 17 6	4 17 6	4 17 6	5 0 0	5 7 6	5 7 6	4 19 9
1897	5 7 6	5 7 6	5 7 6	5 5 0	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 2 6	5 0 0	5 5 0	5 3 5½
1898	5 5 0	5 5 0	5 5 0	5 7 6	5 13 9	5 15 0	5 15 0	5 15 0	5 17 6	6 0 0	6 5 0	6 7 6	5 14 3½
1899	6 10 0	6 12 6	6 15 0	6 15 0	6 17 6	6 17 6	7 0 0	7 0 0	7 5 0	7 5 0	7 12 6	7 15 0	7 0 5
1900	7 15 0	8 0 0	8 2 6	8 5 0	8 5 0	8 7 6	8 7 6	8 2 6	8 2 6	8 0 0	7 10 0	7 10 0	8 0 7
1901	6 15 0	6 12 6	6 5 0	6 0 0	6 0 0	5 10 0	5 15 0	5 17 6	6 0 0	5 17 6	5 17 6	5 15 0	6 0 5½
1902	5 12 6	5 10 0	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 11 8
1903	5 6 3	5 6 3	5 7 6	5 12 6	5 12 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 0 0	5 8 9
1904	5 0 0	4 17 6	5 2 6	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 0 0	5 0 0	5 0 0	5 5 0	5 2 6
1905	5 5 0	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 12 6	6 2 6	6 12 6	6 12 6	5 14 4
1906	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	7 2 6	6 13 4½
1907	6 17 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	6 12 6	6 12 6	7 0 5
1908	6 2 6	6 2 6	6 2 6	5 17 6	5 17 6	5 17 6	5 17 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 16 3
1909	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 9 7
1910	5 16 3	5 17 6	5 17 6	6 1 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 7 6	6 7 6	6 7 6	6 2 3
1911	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 9 0	6 7 8½
1912	6 16 3	6 17 6	6 17 6	7 5 0	7 7 6	7 7 6	7 7 6	7 12 6	7 12 6	7 12 6	7 14 6	7 17 6	7 7 4½
1913	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 11 6	7 7 6	6 15 6	6 7 6	6 2 6	7 8 11½
1914	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	5 15 0	5 15 0	6 15 0	7 0 0	7 0 0	7 1 3	7 5 0	6 8 7½
1915	7 17 0	8 5 0	8 17 6	9 5 0	9 5 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	10 15 0	10 15 0	9 8 3½
1916	11 3 1½	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6½
1917	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1918	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1919	11 2 6	13 12 6	13 12 6	13 12 6	17 2 6	17 1 3	17 0 0	17 15 0	17 15 0	17 15 0	17 17 6	18 5 0	16 1 9½
1920	19 10 0	20 0 0	21 10 0	22 0 0	23 5 0	24 0 0	24 0 0	24 0 0	24 15 0	24 10 0	24 0 0	24 0 0	22 19 2
1921	22 10 0	20 12 6	19 0 0	17 10 0	17 10 0	16 6 0	14 10 0	14 3 4	13 10 0	11 15 0	10 0 0	9 12 6	15 11 7
1922	9 17 6	10 0 0	10 0 0	10 0 0	10 0 0	9 17 6	9 10 9	8 15 7½	8 14 0	8 12 6	8 12 6	8 12 6	9 7 8½
1923	8 18 1½	9 1 3	9 14 0	10 0 0	10 0 0	10 0 0	9 8 9	9 9 6	9 10 0	9 8 9	9 11 6	9 18 9	9 11 8½
1924	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 2	9 11 3	9 15 0	9 15 0	9 9 4½	9 6 6	9 5 0	9 5 0	9 13 1½
1925	9 2 0	9 0 11½	9 0 0	8 15 9	8 10 3½	8 9 0½	8 6 3	8 2 6	7 19 0½	7 12 3	7 5 0	7 2 6	8 5 5½
1926	7 2 6	7 2 6	7 2 6	—	—	—	—	—	—	—	—	—	7 2 6

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WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

18, BENNETTS HILL, BIRMINGHAM.
11, OLD HALL STREET, LIVERPOOL.
EXCHANGE BLDGS., PORT TALBOT.
FOWLERS BUILDINGS, BOMBAY.
CLIVE STREET, CALCUTTA.
ANGAPPA NAICK STREET, MADRAS.

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OCEAN BUILDING, SINGAPORE.
JAVA STREET, KUALA LUMPUR
5, SHAFFRAZ ROAD, RANGOON.
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P.O. BOX 1580, CAIRO.

PIG IRON

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.,

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE

WILLIAM JACKS & COMPANY,

93, HOPE STREET, GLASGOW.

ROYAL EXCHANGE, MIDDLESBROUGH.

SITUATIONS VACANT AND WANTED.

FOREMAN MOULDER, 40 years of age, desires position; experience Marine, Hydraulic, General, Elect., Railroad, Brass or Iron.—Box 686, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

REQUIRED, Representatives for Company manufacturing Foundry Requisites (Core Binder, Core Oils, Fluxes, etc.); state in reply full particulars of experience and ground covered; splendid opportunity to Salesman having already a good connection with Foundries.—Box 692, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

ROLL CASTER.—Wanted, for large Foundry on Continent, experienced Roll Caster for Chilled and Grain Rolls.—Apply in first instance, giving full particulars, to Box 293, c/o JOHN HART & COMPANY, 6, Arundel Street, Strand, W.C.2.

WANTED, Foundry Foreman; must be thoroughly conversant with up-to-date methods, machine plate and general work; used to laying out operations and fixing prices; state fully experience, age and wage required.—Box 694, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

WORKING FOUNDRY FOREMAN required, with good practical experience of Stump and Machine Moulding, small Castings, Cupola work, Annealing by Dowson & Mason Gas Oven; single man preferred; must be good organiser; London district.—Full particulars, Box 678, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

YOUNG FOUNDRY ENGINEER wanted by a large firm in S.W. London; applicants must be 22 to 25 years of age, have had college training, and some practical foundry experience.—Write, stating age, experience and salary required, to Box F.766, c/o DAWSON'S ADVT. OFFICES, 118, Cannon Street, London, E.C.4.

PATENTS.

PATENT YOUR INVENTIONS, Trade-mark your Goods. Advice, Handbook and Cons. free.—B. T. KING, C.I.M.E. (Regd. Pat. Agent, G.B., U.S.A., and Can.), 146A, Queen Victoria Street, E.C.4. 38 years' refs. 'Phone 682 Central.

THE owners of British Patents No. 185,736, entitled "Improvements in Foundry Moulding Machines," and No. 206,624, entitled "Hydraulic Foundry Moulding Machine," desire to dispose of the same, or would grant a licence to work the inventions on royalty terms.—Particulars may be obtained from TECHNICAL RECORDS, LIMITED, of 59-60, Lincoln's Inn Fields, London, W.C.2.

MACHINERY

SAND MIXERS.—New and second-hand. Ask us to quote.—W. BREALEY & COMPANY, LIMITED, Prospect Works, Hawksley Avenue, Sheffield.

FOR SALE.—2½-tons Electro-Metals Steel Furnace, with 700 kw. transformer for 3,000 volt, 50 cycle, three-phase supply; Thury regulators, electrode and tilting motors for 250 volts direct current, control switches, etc.—Apply Box 690, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOR SALE, Steel Rumbler Barrel, barrel 24-in. diameter, 3-ft. 6-in. long, fast and loose pulleys, striking gear.—Box 696, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOR SALE, Cupola Fan and Motor (direct coupled), complete with starter; complete unit in excellent condition, suitable for melting up to 3 tons per hour; full specifications on application; low price for quick sale.—Write, LAWSON, WALTON & COMPANY, LIMITED, Newcastle/Tyne.

Two modern ROOTS BLOWERS, belt driven, 6-in. delivery.

BLOWING FAN, 12-in. delivery.

"Capell" BLOWER, for Smith's Hearths.

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OVERHEAD TRAVELLING CRANES.

One 5-ton Hand operated, 30-ft. 6-in. span.
One 12-ton Hand operated, 24-ft. 6-in. span.
One 20-cwt. Hand operated, 26-ft. 6-in. span.
One 10-cwt. Hand operated, 35-ft. 9-in. span.
One 2-ton Electric operated, 35-ft. 9-in. span.

For further particulars and prices, write to Box 700, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

MACHINERY.—*Continued.*

MACHINERY, PLANT, &c.

HYDRAULIC ACCUMULATOR, 13-in. ram, 16-ft. stroke, M.S. casing, 9-ft. diam., 20-ft. high, 1,500-lbs. pressure.

Nearly New HYDRAULIC INTENSIFIER, rams 17-in. x 9½-in. diam., 5-ft. stroke, hydraulic pressure 1,500 lbs.

250-tons POWERFUL HYDRAULIC PRESS, 22-in. ram, 15,000 lbs. working pressure, by Hy. Berry & Company.

SET OF THREE HYDRAULIC PUMPS, 4½-in. rams, 15-in. stroke, by Hathorn Davey & Company, driven by 250-h.p. A.C. Motor.

FOUR LANCASHIRE BOILERS, 30 ft. x 8 ft., reinsure 150 lbs. pressure.

VERTICAL COCHRAN LAND TYPE BOILER, 14-ft. 9-in. high x 7-ft. diam., heating surface about 500 sq. ft., 100 lbs. working pressure.

CATALOGUE (10,000 LOTS) ON APPLICATION.

THOS W. WARD, LTD.,
ALBION WORKS, SHEFFIELD.

AUCTION SALE.

By Order of the Liquidator, F. Holt, Esq., A.C.A.

GLOBE FOUNDRY, STRATFORD, LD.,
43, CHATSWORTH ROAD, STRATFORD, E.
FREEHOLD AND LEASEHOLD IRON FOUNDRY,
TOGETHER WITH
FOUNDRY AND ENGINEERING PLANT AND MACHINERY.

The premises comprise several buildings of one storey, with Foundry, covering a site area of half an acre. The property has three entrances. A small portion of the premises is held on lease.

The Foundry has an output capacity of approx. 30 tons per week.

LEOPOLD FARMER & SONS will offer the above to Auction, in ONE or MORE LOTS, on the Premises on TUESDAY, 20TH APRIL (unless previously disposed of).

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MISCELLANEOUS.

LETTERS AND FIGURES for Patterns; all sizes; Aluminium; die cast, with pins in one piece; no shellac needed; simply drive them in and they cannot come off. Send for samples and prices.—A. LAKIN & SON, Totley Rise, Sheffield.

PATTERNS.—Inquiries solicited; quotations by return; shop equipped with modern machinery; quick delivery.—CLEGHORN & COMPANY, Midland Pattern Works, Spring Gardens, Worcester. Phone 264.

PATTERNSHOP SUPPLIES. — Full range of Dowels, Rapping Plates, Pattern Letters in stock. Quick deliveries.—LAWSON, WALTON & CO., LTD., Newcastle/Tyne.

BOILER SCALE PREVENTATIVE.—"Zinco-Graphite," our speciality.—Price list and samples from WILLIAM OLSEN, LIMITED, Cogan Street, Hull.

66" **CUPOLA**, by THWAITES, drop bottom, been little used; 10 tons per hour at BLACKBURN £150
ELECTRIC BLOWER by KEITH-BLACKMAN, 12" outlet, with 19 h.p. variable speed motor and starter for above cupola £50
48" **CUPOLA**, by THWAITES, as above, but no spark arrester at BLACKBURN £90
30" **CUPOLETTE**, by CONSTRUCTIONAL CO., with pipes and fan complete... ... ... £32

NEW LADLES—CHEAP.

12 Ton EVANS	£95
5 Ton McNEIL	£38
3 Ton THWAITES	£32
2½ Ton by GEORGE GREEN	£30
2 Ton THWAITES	£26

BUY FROM ME AND SAVE MONEY.

ALEX. HAMMOND. *FOUNDRY MACHINERY MERCHANT,*
14, AUSTRALIA ROAD, SLOUGH.